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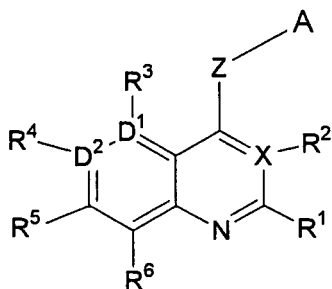
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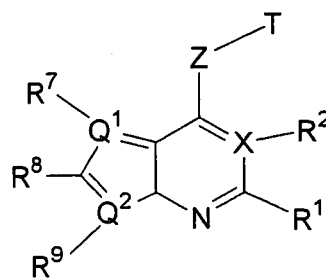
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(54) **COMPOUND HAVING TGF-BETA INHIBITORY ACTIVITY AND PHARMACEUTICAL COMPOSITION CONTAINING SAME**

(57) The present invention provides compounds of formula (I) or compounds of formula (II) and pharmaceutically acceptable salts or solvates thereof. An objective of the present invention is to provide compounds having TGFβ inhibitory activity.



(I)



(II)

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Description

BACKGROUND OF THE INVENTION

5 Field of Invention

[0001] The present invention relates to compounds having TGF β inhibitory activity. The present invention also relates to a pharmaceutical composition useful for the prevention or treatment of diseases for which TGF β inhibition is effective therapeutically.

10 Background Art

[0002] TGF β (transforming growth factor- β) is an important cytokine for living organisms, which regulates growth and differentiation of cells, and repair and regeneration of tissue after its disorder. Disruption of its signal is known to cause onset and progress of various diseases.

Regarding the relationship between TGF β and diseases, the fibrosis of organs or tissues is well known. The fibrosis of an organ or a tissue arise from excessive accumulation of extracellular matrix proteins within the organ, as a defence mechanism against damage of the organ by some cause. The extracellular matrix protein refers to a substance surrounding cells of the tissue. For example, fibrotic proteins such as collagen and elastin, glycoconjugates such as proteoglycan, and glycoproteins such as fibronectin and laminin are mentioned as major extracellular matrix proteins.

[0003] When the level of fibrosis of an organ is low, the organ can be recovered to a normal state without leaving any repair scar. On the other hand, when the level of disorder of the organ is large or when the disorder continues, the fibrosis causes damage to the innate function of the organ. Further, the damage causes new fibrosis to create a vicious cycle. Ultimately, this causes organ failure and, in the worst case, sometimes leads to death.

[0004] TGF β is known to play an important role in the accumulation of the extracellular matrix proteins. For example, the administration of TGF β to normal animals is known to cause fibrosis in various tissues (International Review of Experimental Pathology, 34B: 43-67, 1993). Further, rapid fibrosis of tissues is also observed in trans-genetic mice for TGF β 1 and normal animals with gene-transfer of a TGF β 1 gene, (Proc. Natl. Acad. Sci. USA, 92: 2572-2576, 1995; Laboratory Investigation, 74: 991-1003, 1995).

[0005] TGF β is considered to be involved in the fibrosis of tissues via the following mechanism.

1) TGF β highly increases the level of extracellular matrix proteins such as fibronectin in cells (Journal of Biological Chemistry, 262: 6443-6446, 1987), collagen (Proc. Natl. Acad. Sci. USA, 85 1105-1108, 1988), and proteoglycan (Journal of Biological Chemistry, 263: 3039-3045, 1988).

2) TGF β reduces the expression of degradative enzymes for extracellular matrix proteins (Journal of Biological Chemistry, 263: 16999-17005, 1988) and, in addition, highly promotes the expression of an inhibitor against the degradative enzymes for extracellular matrix proteins (Cancer Research, 49: 2553-2553, 1989). Consequently, the degradation of the extracellular matrix proteins is suppressed.

3) Further, TGF β increases the expression of integrin as a receptor for an extracellular matrix proteins and promotes the deposition of the matrix proteins on cells (Journal of Biological Chemistry, 263: 4586-4592, 1988).

4) Furthermore, TGF β proliferates cells which produce extracellular matrix proteins (American Journal of Physiology, 264: F199-F205, 1993).

[0006] TGF β is known to be mainly involved in the fibrosis of organs such as kidney, liver, lung, heart, bone marrow, and skin.

For example, in the analysis of expression of TGF β 1, an increase in expression of TGF β 1 is observed in diseases such as human acute renal diseases, chronic renal diseases, diabetic nephropathy, renal allograft rejection, HIV nephropathy, hepatic fibrosis, cirrhosis, pulmonary fibrosis, scleroderma, and keloid (New Engl. J. Med., 331, 1286-1292, 1994), and the expression is known to correlate with the expression of extracellular matrix proteins.

[0007] Further, it has been shown that the administration of a soluble form of TGF β type II receptor or an anti-TGF β neutralizing antibody can inhibit fibrosis and pathology in pathologic animal models of renal disease, diabetic nephropathy, hepatic fibrosis, pulmonary fibrosis, and scleroderma (Nature, 346: 371-374, 1990; Journal of the British Thoracic Society, 54: 805-812, 1999; Journal of Immunology, 163: 5693-5699, 1999; Human Gene Therapy, 11: 33-42, 2000; Proc. Natl. Acad. Sci. USA., 97: 8015-20, 2000).

These facts show that the inhibition of TGF β is useful for the prophylaxis and therapy for the diseases involving fibrosis including chronic renal diseases.

[0008] Further, TGF β is also known to be involved in restenosis and arteriosclerosis. In restenosis model animals, an increase in expression of TGF β 1 and its receptor is observed in a disordered blood

vessel, which suggests that TGF β 1 may be involved in the formation of new intima after balloon angioplasty injury (Clinical and Experimental Pharmacology and Physiology 23: 193-200, 1996).

For arteriosclerosis, a high level of expression of TGF β 1 is observed in non-foam macrophage infiltrated in an affected region in which active matrix synthesis takes place (American Journal of Physiology 146: 1140-1149, 1995), which suggests that the non-foam macrophage participates in extracellular matrix protein synthesis within an arteriosclerosis region through TGF β 1.

Further, in a migration test using cells, TGF β 1 is also reported to be a potent stimulating factor for migration of smooth muscle cells causative of arteriosclerosis and vascular restenosis (Biochem Biophys Res Commun., 169: 725-729, 1990).

[0009] TGF β 1 is also involved in wound repair.

For example, an experiment using a neutralizing antibody against TGF β 1 demonstrates that the inhibition of TGF β 1 suppresses excessive scar formation after the injury and is useful for functional recovery. Specifically, it is also known that the administration of a neutralizing antibody against TGF β 1 or TGF β 2 to rats can suppress scar formation and further promotes dermal cell construction via the suppression of dermal fibronectin and collagen deposition and a reduction in the number of monocytes and macrophages (Journal of Cellular Science 108: 985-1002, 1995). In other tissues, the acceleration of cure by the administration of an anti-TGF β -neutralizing antibody is observed in a rabbit corneal injury model and a rat gastric ulcer model (Cornea 16: 177-187, 1997; An international Journal of gastroenterology & Hepatology 39: 172-175, 1996).

[0010] Further, TGF β 1 is also involved in peritoneal adhesion.

For example, it is suggested that the inhibition of TGF β is effective for suppressing peritoneal adhesion and subdermal fibrous adhesion after surgery (J. Surg. Res., 65: 135-138, 1996).

It is reported in a number of articles that the administration of an anti-TGF β neutralizing antibody or a soluble form of TGF β type II receptor into model animals for cancer is also effective for suppressing tumor growth and cancer metastasis (Journal of Clinical Investigation, 92: 2569-76, 1993; Clinical Cancer Research 7: 2931-2940, 2001; Cancer Res. 59: 2210-6, 1999; Journal of Clinical Investigation 109: 1551-1559, 2002; Journal of Clinical Investigation 109: 1607-1615, 2002).

[0011] Tumors is considered to acquire tumor growth potential and metastatic ability by inducing angiogenesis on host side and by lowering immunity of the host side, through TGF β produced by the tumors themselves, on the basis of studies using an anti-TGF β neutralizing antibody. Thus, the inhibition of TGF β is considered to be effective for suppressing cancer metastasis and cancer cell growth.

[0012] It is also reported that an anti-TGF β 1 neutralizing antibody is effective in ex vivo expansion of hematopoietic stem cells (Experimental Hematology 26: 374-381, 1998).

Further, TGF β 1 is known to have growth inhibitory activity against a number of other cell as well as against hematopoietic stem cells.

Accordingly, the inhibition of TGF β is expected to be effective for ex vivo expansion of a number of cells including hematopoietic stem cells.

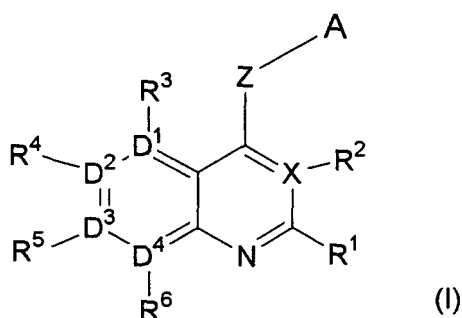
SUMMARY OF THE INVENTION

[0013] The present inventors have now found that a certain group of naphthyridine derivatives, quinoline derivatives, quinazoline derivatives, thienopyridine derivatives, and thienopyrimidine derivatives have inhibitory activity against TGF β 1. The present invention has been made based on such finding.

An object of the present invention is to provide compounds having potent TGF β inhibitory activity.

[0014] In one embodiment of the present invention, there are provided compounds of formula (I) or pharmaceutically acceptable salts or solvates thereof:

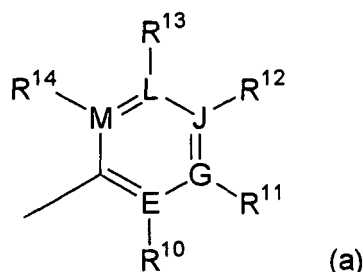
[Chemical formula 1]



wherein

A represents a group of formula (a):

[Chemical formula 2]



Z represents -O-, -N(-R^Z)-, -S-, or -C(=O)- wherein R^Z represents a hydrogen atom or unsubstituted C1-4 alkyl, D¹, D², D³, D⁴, X, E, G, J, L, and M, which may be the same or different, represent C or N, R¹ to R⁶ and R¹⁰ to R¹⁴, which may be the same or different, represent

(1) a hydrogen atom;

(2) a halogen atom;

(3) hydroxyl;

(4) cyano group;

(5) nitro group;

(6) C1-6 alkyl;

(7) C2-6 alkenyl;

(8) C2-6 alkynyl;

(9) C1-6 alkoxy;

(10) C1-6 alkylthio;

wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

(I) hydroxyl,

(II) a halogen atom,

(III) C1-4 alkoxy,

(IV) an oxygen atom,

(V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, or a five- or six-membered carbocyclic or heterocyclic group, and the C1-4 alkyl group is optionally substituted by hydroxyl or phenyl,

(VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl or a five- or six-membered carbocyclic or heterocyclic group, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy,

(VII) -NHCONHR^{VII} wherein R^{VII} represents C1-4 alkyl,

(VIII) -OCOR^{VIII} wherein R^{VIII} represents C1-6 alkyl optionally substituted by amino group, or

(IX) -NSO₂R^{IX} wherein R^{IX} represents C1-4 alkyl;

(11) -NR^aR^b;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

(a) hydroxyl,

- (b) a halogen atom,
 (c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and
 R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom or may contain one or more additional heteroatoms;

- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group;
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;
 (17) -OCOR^k wherein R^k represents C1-4 alkyl; or
 (18) -OSO₂R^L wherein R^L represents C1-4 alkyl,

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group

wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and

R¹⁰ and R¹¹, R¹¹ and R¹², R¹² and R¹³, and R¹³ and R¹⁴ together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, and the carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, provided that, when D¹, D², D³, D⁴, X, E, G, J, L, and M represent a nitrogen atom, groups R² to R⁶ and R¹⁰ to R¹⁴ which attach to the nitrogen atom are absent, and

provided that, when all of D¹, D², D³, and D⁴ represent a carbon atom,

I) at least one of R⁴ and R⁵ represents (4) cyano group, (5) nitro group, (12) -CO-OR^c, (13) -CO-NR^dR^e wherein any one of R^d and R^e represents optionally substituted C1-4 alkyl, (14) carbocyclic group, (15) heterocyclic group

wherein the heterocyclic group contains at least one substituent, or (16) bicyclic carbocyclic group or heterocyclic group, or

II) L represents a nitrogen atom, E, G, J, and M represent a carbon atom, R¹⁰ represents a hydrogen atom, and R¹⁴ represents (6) C1-6 alkyl group, (14) carbocyclic group, (15) heterocyclic group, or (16) bicyclic carbocyclic group or heterocyclic group.

[0015] In another embodiment of the present invention, formula (I) may also be defined as follow:

That is, in formula (I),

A represents a group of formula (a),

Z represents -O-, -N(-R^Z)-, -S-, or -C(=O)- wherein R^Z represents a hydrogen atom or unsubstituted C1-4 alkyl, D¹, D², D³, D⁴, X, E, G, J, L, and M, which may be the same or different, represent C or N, R¹ to R⁶ and R¹⁰ to R¹⁴, which may be the same or different, represent

- (1) a hydrogen atom;
 (2) a halogen atom;
 (3) hydroxyl;
 (4) cyano group;
 (5) nitro group;
 (6) C1-6 alkyl;
 (7) C2-6 alkenyl;
 (8) C2-6 alkynyl;
 (9) C1-6 alkoxy;
 (10) C1-6 alkylthio;

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wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

- 5 (I) hydroxyl,
(II) a halogen atom,
(III) C1-4 alkoxy,
(IV) an oxygen atom,
(V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
10 (VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy,

- (11) -NR^aR^b;
(12) -CO-OR^c;
15 (13) -CO-NR^dR^e;

wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

- 20 (a) hydroxyl,
(b) a halogen atom,
(c) C1-4 alkoxy,
(d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
(e) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4
25 alkyl, and
R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom or may contain one or more additional heteroatoms;

- 30 (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group
35 wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and
R¹⁰ and R¹¹, R¹¹ and R¹², R¹² and R¹³, and R¹³ and R¹⁴ together may combine with the carbon atoms to which they
40 are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, and the carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl,
45 provided that, when D¹, D², D³, D⁴, X, E, G, J, L, and M represent a nitrogen atom, groups R² to R⁶ and R¹⁰ to R¹⁴ which attach to the nitrogen atom are absent, and
provided that, when all of D¹, D², D³, and D⁴ represent a carbon atom,

- I) at least one of R⁴ and R⁵ represents (4) cyano group, (5) nitro group, (12) -CO-OR^c, (13) -CO-NR^dR^e
50 wherein any one of R^d and R^e represents optionally substituted C1-4 alkyl, (14) carbocyclic group, (15) heterocyclic group
wherein the heterocyclic group contains at least one substituent, or (16) bicyclic carbocyclic group or heterocyclic group, or
II) L represents a nitrogen atom, E, G, J, and M represent a carbon atom, R¹⁰ represents a hydrogen atom, and
55 R¹⁴ represents (6) C1-6 alkyl group, (14) carbocyclic group, (15) heterocyclic group, or (16) bicyclic carbocyclic group or heterocyclic group.

[0016] In one preferred embodiment of the present invention, in formula (I), at least one of D¹ to D⁴ represents a

nitrogen atom.

[0017] In another preferred embodiment of the present invention, in formula (I),

all of D¹ to D⁴ represent a carbon atom,

R¹ and R² represent a hydrogen atom,

R³ and R⁶, which may be the same or different, represent a hydrogen atom, a halogen atom, or C1-4 alkyl, and

R⁴ and R⁵, which may be the same or different, represent

(4) cyano group;

(5) nitro group;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

wherein, in groups (12) and (13), R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or, C1-4 alkyl, provided that at least one of R^d and R^e represents C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

(a) hydroxyl,

(b) a halogen atom,

(c) C1-4 alkoxy,

(d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or

(e) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl,

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

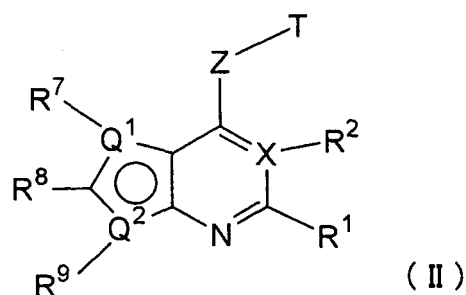
(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and (15) heterocyclic group contains at least one substituent.

[0018] In one embodiment of the present invention, there are provided compounds of formula (II) or pharmaceutically acceptable salts or solvates thereof:

[Chemical formula 3]



wherein

T represents a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, wherein group T is optionally substituted by groups (2) to (16):

(2) a halogen atom;

(3) hydroxyl;

(4) cyano group;

(5) nitro group;

(6) C1-6 alkyl;

(7) C2-6 alkenyl;

- (8) C2-6 alkynyl;
 (9) C1-6 alkoxy;
 (10) C1-6 alkylthio;

wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

- (I) hydroxyl,
 (II) a halogen atom,
 (III) C1-4 alkoxy,
 (IV) an oxygen atom,
 (V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy,

- (11) $-NR^aR^b$;
 (12) $-CO-OR^c$;
 (13) $-CO-NR^dR^e$;

wherein, in groups (11) to (13), R^a , R^b , R^c , R^d , and R^e , which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

- (a) hydroxyl,
 (b) a halogen atom,
 (c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and
 R^d and R^e together may combine with the carbon atoms to which they are attached to represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom or may contain one or more additional heteroatoms;

- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) $-CO-OR^f$, or (xii) $-CO-NR^gR^h$ wherein R^f , R^g , and R^h , which may be the same or different, represent a hydrogen atom or C1-4 alkyl,

two adjacent substituents on group T together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, and the carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) $-CO-OR^f$, or (xii) $-CO-NR^gR^h$ wherein R^f , R^g , and R^h , which may be the same or different, represent a hydrogen atom or C1-4 alkyl,

[0019] Q^1 and Q^2 , which may be the same or different, represent C, S, O, or N,

X represents C or N,

Z represents $-O-$, $-N(-R^Z)-$, $-S-$, or $-C(=O)-$ wherein R^Z represents a hydrogen atom or unsubstituted C1-4 alkyl, R^1 , R^2 , and R^7 to R^9 , which may be the same or different, represent,

- (1) a hydrogen atom;
 (2) a halogen atom;
 (3) hydroxyl;
 (4) cyano group;
 (5) nitro group;
 (6) C1-6 alkyl;

- (7) C2-6 alkenyl;
 (8) C2-6 alkynyl;
 (9) C1-6 alkoxy;
 (10) C1-6 alkylthio;

5 wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

- (I) hydroxyl,
 (II) a halogen atom,
 10 (III) C1-4 alkoxy,
 (IV) an oxygen atom,
 (V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4
 15 alkyl, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy;

- (11) -NR^aR^b;
 (12) -CO-OR^c;
 (13) -CO-NR^dR^e;

20 wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and C1-4 alkyl is optionally substituted by

- (a) hydroxyl,
 (b) a halogen atom,
 25 (c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4
 30 alkyl, and

R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom and may contain one or more additional heteroatoms;

- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 35 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,
 wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group
 wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl,
 40 (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and
 the five-membered ring part containing Q¹ and Q² in formula (II) represents an aromatic ring,
 provided that, when X represents a nitrogen atom, R² is absent, and
 when Q¹ and Q² represent an oxygen atom or a sulfur atom, R⁷ and R⁹ which attach to the oxygen atom or the
 45 sulfur atom are absent, and, when both Q¹ and Q² represent a nitrogen atom, any one of R⁷ and R⁹ is absent.

[0020] The compounds according to the present invention can be used for the treatment and prevention of diseases for which TGF β inhibition is effective therapeutically or prophylactically.

Diseases for which TGF β inhibition is effective therapeutically or prophylactically include, for example, chronic renal disease, acute renal disease, hepatic fibrosis, cirrhosis, pulmonary fibrosis, scleroderma, wound healing, arthritis, congestive cardiac disease, ulcer, ocular disorder, corneal problem, diabetic nephropathy, peritoneal sclerosis, arteriosclerosis, peritoneal adhesions, and subdermal adhesion and, further, malignant tumors.

Accordingly, the compounds according to the present invention can be useful for the prevention or treatment of these diseases. The compounds according to the present invention can also be useful for ex vivo expansion of hematopoietic stem cells.

The pharmaceutical composition according to the present invention comprises a compound of formula (I) or (II) according to the present invention as an active component.

The TGF β inhibitor according to the present invention comprises a compound according to the present invention.

[0021] The method for treating or preventing a disease for which TGF β inhibition according to the present invention is effective therapeutically or prophylactically, comprises the step of administering a therapeutically or prophylactically effective amount of a compound of formula (I) or (II) or a pharmaceutically acceptable salt or solvate thereof into a patient requiring the treatment or prevention of the disease for which TGF β inhibition is effective therapeutically or prophylactically.

The method for ex vivo expansion according to the present invention comprises the step of adding a compound of formula (I) or (II) or a pharmaceutically acceptable salt or solvate thereof into intended cells in vitro to amplify the cells, at an amount effective for promoting cell growth.

DETAILED DESCRIPTION OF THE INVENTION

Compounds according to invention

[0022] The term "alkyl," "alkoxy," "alkenyl," "alkynyl," and "alkylthio" as used herein as a group or a part of a group respectively mean straight chain or branched chain alkyl, alkoxy, alkenyl, alkynyl, and alkylthio.

Accordingly, in the present specification, for example, "C1-6 alkyl" and "C1-6 alkoxy" as a group or a part of a group respectively mean straight chain or branched chain alkyl and alkoxy having 1 to 6 carbon atoms.

[0023] "C1-6 alkyl" is preferably C1-4 alkyl, more preferably C1-3 alkyl, still more preferably C1-2 alkyl. "C1-4 alkyl" is preferably C1-3 alkyl, more preferably C1-2 alkyl.

"C1-6 alkoxy" is preferably C1-4 alkoxy, more preferably C1-3 alkoxy, still more preferably C1-2 alkoxy. "C1-4 alkoxy" is preferably C1-3 alkoxy, more preferably C1-2 alkoxy.

[0024] "C2-6 alkenyl" is preferably C2-5 alkenyl, more preferably C2-4 alkenyl, still more preferably C2-3 alkenyl. "C2-4 alkenyl" is preferably C2-3 alkenyl, more preferably C2 alkenyl.

"C2-6 alkynyl" is preferably C2-5 alkynyl, more preferably C2-4 alkynyl, still more preferably C2-3 alkynyl. "C2-4 alkynyl" is preferably C2-3 alkynyl, more preferably C2 alkynyl.

"C1-6 alkylthio" is preferably C1-4 alkylthio, more preferably C1-3 alkylthio, still more preferably C1-2 alkylthio. "C1-4 alkylthio" is preferably C1-3 alkylthio, more preferably C1-2 alkylthio.

[0025] Examples of C1-6 alkyl include methyl, ethyl, n-propyl, isopropyl, n-butyl, i-butyl, s-butyl, t-butyl, n-pentyl, and n-hexyl.

Examples of C1-6 alkoxy include methoxy, ethoxy, n-propoxy, i-propoxy, n-butoxy, i-butoxy, s-butoxy, and t-butoxy.

Examples of C2-6 alkenyl include allyl, butenyl, pentenyl, and hexenyl.

Examples of C2-6 alkynyl include 2-propynyl, butynyl, pentynyl, and hexynyl.

Examples of C1-6 alkylthio include methylthio, ethylthio, n-propylthio, isopropylthio, n-butylthio, i-butylthio, and s-butylthio.

[0026] In the present specification, alkyl "optionally substituted by" means either alkyl in which one or more hydrogen atoms on the alkyl group may be substituted by one or more substituents (which may be the same or different), or unsubstituted alkyl. It will be apparent to a person having ordinary skill in the art that the maximum number of substituents may be determined depending upon the number of substitutable hydrogen atoms on alkyl. This is true of groups that contain a group which is other than alkyl and is substitutable, for example, carbocyclic groups such as alkylthio, alkoxy, alkenyl, alkynyl, and phenyl, heterocyclic groups such as pyridyl, or bicyclic groups such as naphthyl.

[0027] Further, C1-6 alkyl optionally substituted by "an oxygen atom" mainly means such a state that one oxygen atom may be substituted for two hydrogen atoms on an identical carbon atom on alkyl, that is, the case where a ketone may be formed. This, however, does not exclude the case where a cyclic ether structure such as oxirane is formed. Accordingly, examples of C1-6 alkyl optionally substituted by "an oxygen atom" include ethan-1-one, propan-1-one, propan-2-one, butan-1-one, and butan-2-one. This is true of alkenyl, alkynyl, alkoxy, and alkylthio.

[0028] The term "halogen atom" as used herein means a fluorine, chlorine, bromine, or iodine atom.

[0029] The term "unsaturated carbocyclic ring" and "unsaturated heterocyclic ring" means a carbocyclic or heterocyclic ring containing one or more unsaturated bonds such as a double bond.

[0030] The "saturated or unsaturated three- to nine-membered carbocyclic group" is preferably a saturated or unsaturated five- to seven-membered carbocyclic group, more preferably a saturated or unsaturated five- or six-membered carbocyclic group. Examples of saturated or unsaturated three- to nine-membered carbocyclic rings include phenyl, cyclopropyl, cyclobutyl, cyclopentyl, cyclohexyl, and cycloheptyl.

[0031] The "saturated or unsaturated three- to nine-membered heterocyclic group" contains one or more heteroatoms selected from an oxygen atom, a nitrogen atom, and a sulfur atom. The saturated or unsaturated three- to nine-membered heterocyclic group is preferably a heterocyclic ring containing one, two or three heteroatoms and the remaining ring atoms being a carbon atom. The saturated or unsaturated three- to nine-membered heterocyclic group is preferably a saturated or unsaturated five- to seven-membered heterocyclic group, more preferably a saturated or unsaturated five- or six-membered heterocyclic group. Examples of saturated or unsaturated three- to nine-membered heterocyclic groups

include thienyl, pyridyl, 1,2,3-triazolyl, thiazolyl, imidazolyl, isoxazolyl, pyrazolyl, piperaziny, piperazino, piperidyl, piperidino, morpholinyl, morpholino, homopiperaziny, homopiperazino, thiomorpholinyl, thiomorpholino, tetrahydropyrrolyl, and azepanyl.

[0032] When the carbocyclic or heterocyclic group is substituted by two alkyl groups, the two alkyl groups together may form an alkylene chain, preferably a C1-3 alkylene chain. Azabicyclo[2.2.2]octanyl, bicyclo[2.2.2]octanyl, and norbornanyl may be mentioned as the carbocyclic or heterocyclic group having the above crosslinked structure.

[0033] The "bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group" is preferably bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group. When the bicyclic group is a heterocyclic group, the bicyclic group contains one or more heteroatoms selected from oxygen, nitrogen, and sulfur atoms. Examples of such bicyclic groups include indolizine, indole, isoindole, benzofuran, benzothiophene, indazole, benzimidazole, benzothiazole, purine, quinoline, isoquinoline, cinnoline, phthalazine, quinazoline, quinoxaline, naphthyridine, and naphthalene.

[0034] In one preferred embodiment of the present invention, in formula (I), at least one of D¹ to D⁴ represents a nitrogen atom. In this case, more preferably when at least one of D¹ and D² is a nitrogen atom, both D³ and D⁴ represent a carbon atom.

Still more preferably, D¹ represents a nitrogen atom, and all of D² to D⁴ represent a carbon atom, or D² represents a nitrogen atom, and all of D¹, D³, and D⁴ represent a carbon atom. In these cases, more preferably, X represents a carbon atom.

[0035] In formula (II), Q¹ and Q² are preferably selected from carbon and sulfur atoms. More preferably, any one of Q¹ and Q² represents a sulfur atom, and the other represents a carbon atom or a sulfur atom. Still more preferably, Q¹ represents a sulfur atom, and Q² represents a carbon atom, or

Q¹ represents a carbon atom, and Q² represents a sulfur atom. Still more preferably, when Q¹ represents a carbon atom and, at the same time, Q² represents a sulfur atom, X represents a nitrogen atom, or when Q¹ represents a sulfur atom and, at the same time, Q² represents a carbon atom, X represents a nitrogen atom, or when Q¹ represents a sulfur atom and, at the same time, Q² represents a carbon atom, X represents a carbon atom.

[0036] Preferably, Z represents -O-, -NH-, -S-, or -C(=O)-, more preferably -O- or -NH-, still more preferably -O-.

[0037] Preferably, R¹, R², and R³ independently represent a hydrogen atom, a halogen atom, or C1-4 alkyl, more preferably a hydrogen atom, a halogen atom, or methyl, still more preferably a hydrogen atom.

[0038] In one preferred embodiment of the present invention, when X represents a carbon atom, both R¹ and R² represent a hydrogen atom.

In this case, more preferably, when D¹ represents a nitrogen atom and, at the same time, all of D² to D⁴ represent a carbon atom, R⁶ represents a hydrogen atom.

Alternatively, in this case, more preferably when D² represents a nitrogen atom and, at the same time, all of D¹, D³, and D⁴ represent a carbon atom, R³ represents a hydrogen atom or a halogen atom while R⁶ represents a hydrogen atom.

[0039] R⁴ and R⁵, and R⁷ to R⁹, which may be the same or different, preferably represent

- (1) a hydrogen atom ;
- (2) a halogen atom;
- (3) hydroxyl;
- (6) C1-6 alkyl;
- (9) C1-6 alkoxy;
- (12) -CO-OR^c;
- (13) -CO-NR^dR^e;
- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
- (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
- (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group, wherein these groups are optionally substituted as defined above.

[0040] More preferably, R⁴ and R⁵, and R⁷ to R⁹, which may be the same or different, represent

- (1) a hydrogen atom;
- (2) a halogen atom;
- (6') C1-4 alkyl optionally substituted by a halogen atom;
- (9') C1-4 alkoxy optionally substituted by a halogen atom;
- (12') -CO-OR^c;
- (13') -CO-NR^dR^e;

wherein, in groups (12') and (13'), R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-2 alkyl, and the C1-2 alkyl group is optionally substituted by

- (a) hydroxyl,
 (b) a halogen atom,
 (d') a saturated or an unsaturated five- or six-membered carbocyclic or heterocyclic group, or
 (e) amino;

(14') a saturated or unsaturated five- or six-membered carbocyclic group; or
 (15') a saturated or unsaturated five- or six-membered heterocyclic group,
 wherein (14') carbocyclic group and (15') heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0041] Still more preferably, R⁴ and R⁵, and R⁷ to R⁹, which may be the same or different, represent

- (1) a hydrogen atom;
 (2) a halogen atom;
 (6) C1-6 alkyl; or
 (9) C1-6 alkoxy;

wherein (6) C1-6 alkyl and (9) C1-6 alkoxy are optionally substituted as defined above.

[0042] More preferably, R⁴ and R⁵, and R⁷ to R⁹, which may be the same or different, represent a hydrogen atom, a halogen atom, or C1-4 alkyl.

[0043] In one more preferred embodiment of the present invention, R⁴ and R⁵ represent a hydrogen atom.

[0044] In another embodiment of the present invention, R⁴ represents optionally substituted C1-6 alkoxy, and R⁵ represents a hydrogen atom, a halogen atom, or -CO-NH₂. More preferably, R⁴ represents C1-6 alkoxy substituted by hydroxyl, still more preferably -O(CH₂)_{m1}-OH wherein m₁ is an integer of 2 to 4, still more preferably -OC₂H₅-OH.

[0045] In a more preferred embodiment of the present invention, R⁷ and R⁹ represent a hydrogen atom, a halogen atom, or C1-4 alkyl, still more preferably a hydrogen atom, a halogen atom, or methyl.

[0046] In still more preferred embodiment of the present invention, R⁸ represents a hydrogen atom,

a halogen atom,
 C1-4 alkyl,

a saturated or unsaturated six-membered carbocyclic group, or
 a saturated or unsaturated six-membered heterocyclic group,

wherein the carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0047] In a still more preferred embodiment of the present invention, R⁷ and R⁹ represent a hydrogen atom, a halogen atom, or C1-4 alkyl. In this case,

R⁸ represents

a hydrogen atom,

a halogen atom,

C1-4 alkyl,

a saturated or unsaturated six-membered carbocyclic group, or

a saturated or unsaturated six-membered heterocyclic group,

wherein the carbocyclic and heterocyclic groups are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0048] In one preferred embodiment of the present invention, when X represents a carbon atom, both R¹ and R² represent a hydrogen atom.

In this case, more preferably, when Q¹ represents a sulfur atom and, at the same time, Q² represents a carbon atom, R⁹ represents a hydrogen atom.

Alternatively, in this case, more preferably, when Q¹ represents a carbon atom and, at the same time, Q² represents a sulfur atom, R⁷ represents a hydrogen atom.

[0049] In another embodiment of the present invention, R⁴ and R⁵, and R⁷ to R⁹ independently may represent group -OR^X

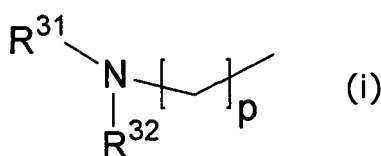
wherein R^X represents a hydrogen atom or -(CH₂)_m-R^{aX} wherein R^{aX} represents a hydrogen atom, a halogen atom, hydroxyl, a saturated or unsaturated three- to six-membered carbocyclic or heterocyclic group, C1-4 alkoxy, C1-4 alkoxycarbonyl, or -NR^{bX}R^{cX} wherein R^{bX} and R^{cX}, which may be the same or different, represent a hydrogen atom, or C1-6 alkyl optionally substituted by hydroxyl, an oxygen atom, amino group, a nitrogen atom, or C1-4 alkyl, and R^{bX} and R^{cX} together may combine with nitrogen atoms to which they are attached represent a saturated or unsaturated five- or six-

membered heterocyclic group wherein the heterocyclic group may contain one or more heteroatoms. The heterocyclic group is optionally substituted by C1-4 alkyl optionally substituted by hydroxyl; hydroxyl; an oxygen atom; aminocarbonyl; C1-4 alkoxy; C1-4 alkoxy carbonyl; or a saturated or unsaturated five- or six-membered heterocyclic group. The heterocyclic group may condense with another saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group to form a bicyclic group. m is an integer of 1 to 6. The alkyl chain part $-(CH_2)_m-$ in this group is optionally substituted by hydroxyl; an oxygen atom; $-OR^{dX}$ wherein R^{dX} represents C1-4 alkyl or C1-4 alkylcarbonyl; or C1-4 alkyl optionally substituted by hydroxyl or a halogen atom.

[0050] In still another preferred embodiment of the present invention, R^4 and R^5 , and R^7 to R^9 independently may represent group $-OR^m$ wherein R^m represents groups of formulae (i) to (vi):

(i) a group of formula (i):

[Chemical formula 4]



wherein

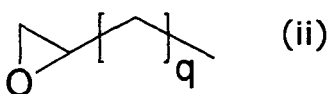
R^{31} and R^{32} , which may be the same or different, represent a hydrogen atom, or

C1-6 alkyl optionally substituted by hydroxyl, an oxygen atom, amino group, or a nitrogen atom,

R^{31} and R^{32} together may combine with the nitrogen atom to which they are attached represent a saturated or unsaturated five- or six-membered heterocyclic group wherein the heterocyclic group may contain one or more additional heteroatoms and is optionally substituted by C1-4 alkyl optionally substituted by hydroxyl; hydroxyl; an oxygen atom; aminocarbonyl; C1-4 alkoxy; C1-4 alkoxy carbonyl; or a saturated or unsaturated five- or six-membered heterocyclic group, and, further, the heterocyclic group optionally formed by combining R^{31} with R^{32} may condense with another saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group to represent a bicyclic group, p is an integer of 2 to 4, preferably 2 or 3, and the alkyl chain part in this group is optionally substituted by hydroxyl or group $-OR^i$ wherein R^i represents C1-4 alkyl or C1-4 alkylcarbonyl;

[0051] (ii) a group of formula (ii):

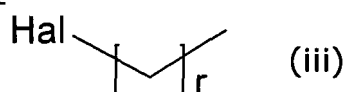
[Chemical formula 5]



wherein q is an integer of 1 to 4, preferably 1 or 2;

(iii) a group of formula (iii):

[Chemical formula 6]

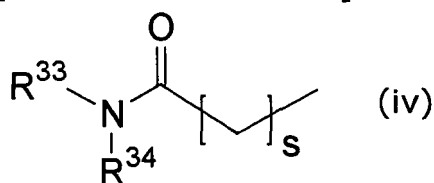


wherein Hal represents a halogen atom, preferably a fluorine atom or a chlorine atom, and

r is an integer of 2 to 4, preferably 2 or 3;

[0052] (iv) a group of formula (iv):

[Chemical formula 7]



wherein

R³³ and R³⁴, which may be the same or different, represent

a hydrogen atom or

C₁₋₆ alkyl optionally substituted by hydroxyl,

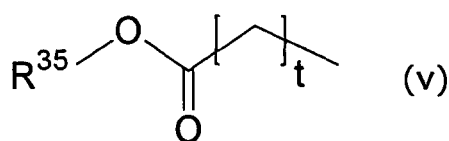
R³³ and R³⁴ may combine with the nitrogen atom to which they are attached represent a saturated or unsaturated five- or six-membered heterocyclic group wherein the heterocyclic group may contain one or more additional heteroatoms and is optionally substituted by C1-4 alkyl optionally substituted by hydroxyl; or a saturated or unsaturated five- or six-membered heterocyclic group, and, further, the heterocyclic group optionally formed by combining R³³ with R³⁴ may condense with another saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group to represent a bicyclic group, and

s is an integer of 0 to 3, preferably 0 to 2;

[0053]

(v) a group of formula (v):

[Chemical formula 8]



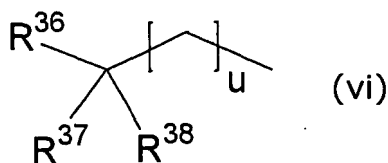
wherein

R³⁵ represents C1-4 alkyl, and

t is an integer of 0 to 3, preferably 0 to 2; and

(vi) a group of formula (vi):

[Chemical formula 9]



wherein

R³⁶, R³⁷ and R³⁸, which may be the same or different, represent

a hydrogen atom,

C1-4 alkoxy carbonyl, or

C1-4 alkyl optionally substituted by hydroxyl or a halogen atom, and

u is an integer of 0 to 4, preferably 0 to 2, more preferably 0 or 1.

[0054] Preferably, R⁶ represents a hydrogen atom, a halogen atom, or C1-4 alkyl, more preferably a hydrogen atom, a halogen atom, or methyl, still more preferably a hydrogen atom.

[0055] In a preferred embodiment of the present invention, in formula (I), when R¹ and R² represent a hydrogen atom, R³ and R⁶ represent a hydrogen atom, a halogen atom, or C1-4 alkyl. More preferably, all of R¹, R², R³, and R⁶ represent a hydrogen atom.

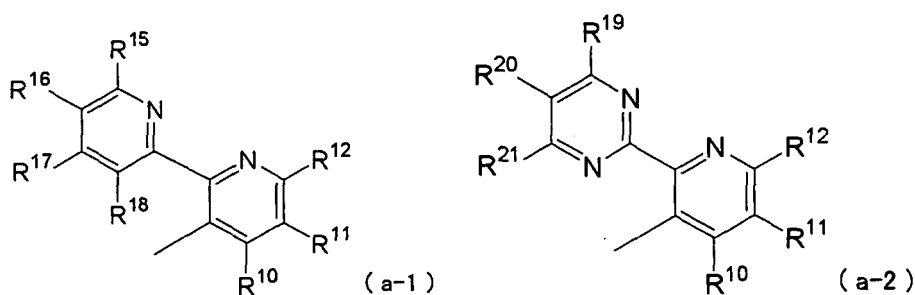
[0056] In one preferred embodiment of the present invention, in formula (I), when R³ represents a hydrogen atom, Z represents -O-.

[0057] In a preferred embodiment of the present invention, in formula (II), both R¹ and R² represent a hydrogen atom.

[0058] In formula (I), when group A may represent a group of formula (a), preferably, in formula (a), any one of E, G, J, L, and M represents a nitrogen atom, and all the other groups represent a carbon atom. More preferably, L represents a nitrogen atom, and E, G, J and M represent a carbon atom.

[0059] In one preferred embodiment of the present invention, in formula (I), group A represents a group of formula (a-1) or (a-2):

[Chemical formula 10]



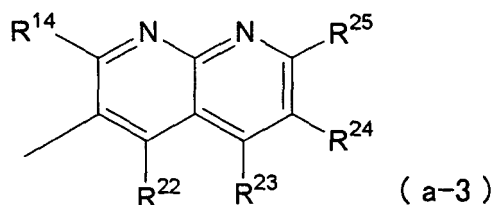
wherein

R¹⁰ to R¹² are as defined above, and

R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, represent (0) a hydrogen atom, (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

[0060] In another preferred embodiment of the present invention, in formula (I), group A represents a group of formula (a-3):

[Chemical formula 11]



wherein

R¹⁴ is as defined above, and

R²² to R²⁵, which may be the same or different, represent (0) a hydrogen atom, (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom

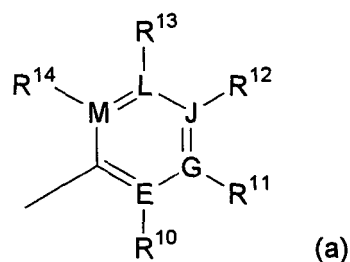
or C1-4 alkyl.

[0061] In formula (II), preferably, group T represents a unsaturated six-membered carbocyclic or heterocyclic group optionally substituted by groups (2) to (16), more preferably an unsaturated six-membered heterocyclic group optionally substituted by groups (2) to (16). In this case, the heteroatom in the heterocyclic group is preferably a nitrogen atom.

When the two adjacent substituents on group T together combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, bicyclic groups which may be formed by group T include, for example, indolizine, indole, isoindole, benzofuran, benzothiophene, indazole, benzimidazole, benzothiazole, purine, quinoline, isoquinoline, cinnoline, phthalazine, quinazoline, quinoxaline, naphthyridine, and naphthalene.

[0062] In formula (II), more preferably, group T represents a group of formula (a):

[Chemical formula 12]



wherein

E, G, J, L, and M, which may be the same or different, represent C or N, and R¹⁰ to R¹⁴, which may be the same or different, represent

- (1) a hydrogen atom;
- (2) a halogen atom;
- (3) hydroxyl;
- (4) cyano group;
- (5) nitro group;
- (6) C1-6 alkyl;
- (7) C2-6 alkenyl;
- (8) C2-6 alkynyl;
- (9) C1-6 alkoxy;
- (10) C1-6 alkylthio;

wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

- (I) hydroxyl,
- (II) a halogen atom,
- (III) C1-4 alkoxy,
- (IV) an oxygen atom,
- (V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
- (VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy,

- (11) -NR^aR^b;
- (12) -CO-OR^c;
- (13) -CO-NR^dR^e;

wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

- (a) hydroxyl,
- (b) a halogen atom,

(c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and
 R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom or may contain one or more additional heteroatoms;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;
 wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and R¹⁰ and R¹¹, R¹¹ and R¹², R¹² and R¹³, and R¹³ and R¹⁴ together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, and the carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl,
 provided that, when E, G, J, L, and M represent a nitrogen atom, groups R¹⁰ to R¹⁴ which attach to the nitrogen atom are absent.

[0063] In formula (II), when group T may represent a group of formula (a), preferably, in formula (a), any one of E, G, J, L, and M represents a nitrogen atom, and all the other groups represent a carbon atom. More preferably, L represents a nitrogen atom, and E, G, J and M represent a carbon atom.

[0064] In a further preferred embodiment of the present invention, in formula (II), group T represents a group of formula (a-1) or (a-2) wherein the substituents are as defined above. In another preferred embodiment of the present invention, in formula (II), group T represents a group of formula (a-3) wherein the substituents are as defined above.

[0065] In the group of formula (a-1) or (a-2) in formula (I) and formula (II), preferably, R¹⁵ to R¹⁸ and R¹⁹ to R²¹ are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, more preferably selected from the group consisting of a hydrogen atom, a halogen atom, methyl, and methoxy. Still more preferably, all of these groups represent a hydrogen atom.

[0066] In the group of formula (a-3), preferably, R²² to R²⁵ are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, more preferably selected from the group consisting of a hydrogen atom, a halogen atom, and C1-4 alkyl, still more preferably selected from the group consisting of a hydrogen atom, a halogen atom, and methyl. Further preferably, all of R²² to R²⁵ represent a hydrogen atom.

[0067] Preferably, R¹⁰ represents a hydrogen atom, a halogen atom, or methyl, more preferably a hydrogen atom.

[0068] In a preferred embodiment of the present invention, R¹¹ and R¹² independently are selected from the group consisting of a hydrogen atom, a halogen atom, and C1-4 alkyl, more preferably selected from the group consisting of a hydrogen atom and C1-4 alkyl. More preferably, at least one of R¹¹ and R¹² represents C1-4 alkyl and the other represents a hydrogen atom or C1-4 alkyl, still more preferably are selected from the group consisting of a hydrogen atom, methyl, and ethyl. More preferably, both R¹¹ and R¹² represent methyl. Alternatively, R¹¹ represents a hydrogen atom, and R¹² represents methyl or ethyl.

[0069] In a more preferred embodiment of the present invention, when R¹¹ and R¹² are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, preferably when selected from the group consisting of a hydrogen atom and C1-4 alkyl, R¹⁰ represents a hydrogen atom. Still more preferably, in the group of formula (a-1) or (a-2), R¹⁵ to R¹⁸ and R¹⁹ to R²¹ are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy. Most preferably, in the group of formula (a-1) or (a-2), all of R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.

[0070] In another preferred embodiment of the present invention, R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group. In this case, preferably, R¹⁰ represents a hydrogen atom. More preferably, R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent an unsaturated six-membered carbocyclic or heterocyclic group. Still more

preferably, R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent an unsaturated six-membered heterocyclic group.

[0071] When R¹⁰, R¹¹ and R¹² are as defined above, in a preferred embodiment of the present invention, Z represents -O-, X represents a carbon atom, and R¹ to R³ and R⁶ represent a hydrogen atom.

[0072] When R¹³ is present, R¹³ preferably represents a hydrogen atom, a halogen atom, or methyl, more preferably a hydrogen atom.

[0073] Preferably, R¹⁴ represents optionally substituted C1-4 alkyl or

an optionally substituted saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group. Here regarding the C1-4 alkyl group, the term "optionally substituted" means that, as with "(6) C1-6 alkyl" in formula (I) or formula (II), the alkyl group may be substituted. Further, the term "optionally substituted" in the carbocyclic or heterocyclic group means that, as with "(14) carbocyclic group" or "(15) heterocyclic group" in formula (I) or (II), the carbocyclic or heterocyclic group may be substituted.

[0074] When R¹¹ and R¹² are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, preferably selected from the group consisting of a hydrogen atom and C1-4 alkyl, preferably R¹⁴ represents an optionally substituted saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group. In this case, more preferably, R¹⁴ represents an optionally substituted unsaturated six-membered heterocyclic group, still more preferably 2-pyridyl or 2,6-pyrimidyl.

[0075] When R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, preferably, R¹⁴ represents optionally substituted C1-4 alkyl or an optionally substituted saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group. The C1-4 alkyl group which may be represented by R¹¹ and R¹² is preferably unsubstituted C1-4 alkyl. The carbocyclic or heterocyclic group which may be represented by R¹¹ and R¹² is preferably an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group, more preferably phenyl optionally substituted by hydroxyl, a halogen atom, amino group, C1-4 alkyl, or C1-4 alkoxy, still more preferably phenyl optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

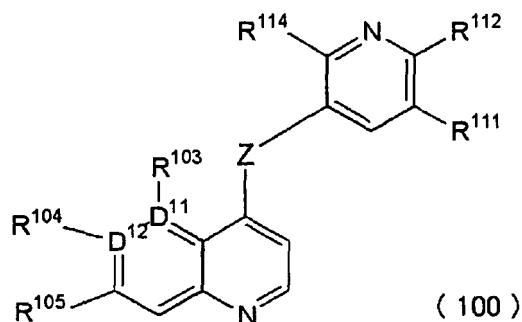
[0076] When A represents a group of formula (a-3), R¹⁴ preferably represents

optionally substituted C1-4 alkyl,

an optionally substituted, saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, or an optionally substituted bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group. In a more preferred embodiment, R¹⁴ represents unsubstituted C1-4 alkyl. In another preferred embodiment, R¹⁴ represents an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group, more preferably phenyl optionally substituted by hydroxyl, a halogen atom, amino group, C1-4 alkyl, or C1-4 alkoxy, still more preferably phenyl optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0077] In a preferred embodiment of the present invention, the compound of formula (I) may be a compound of formula (100):

[Chemical formula 13]



wherein

Z represents -O-, -NH-, -S-, or -C(=O)-, preferably -O- or -NH-, more preferably -O-,

any one of D¹¹ and D¹² represents a nitrogen atom, and the other represents a carbon atom,

R¹⁰³ represents a hydrogen atom or a halogen atom, preferably a hydrogen atom,

R¹⁰⁴ and R¹⁰⁵, which may be the same or different, represent

- (1) a hydrogen atom ;
 (2) a halogen atom;
 (3) hydroxyl;
 (6) C1-6 alkyl;
 (9) C1-6 alkoxy;
 (12) -CO-OR^c;
 (13) -CO-NR^dRe;
 (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,
 wherein these groups are optionally substituted as in the definition of formula (I), R¹¹¹ and R¹¹², which may be the
 same or different, are selected from the group consisting of a hydrogen atom, C1-4 alkyl, and C1-4 alkoxy, preferably
 selected from the group consisting of a hydrogen atom and C1-4 alkyl, more preferably selected from the group
 consisting of a hydrogen atom, methyl, and ethyl,
 R¹¹⁴ represents
 (14") a saturated or unsaturated five- or six-membered carbocyclic group;
 (15") a saturated or unsaturated five- or six-membered heterocyclic group; or
 (16") a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;
 wherein (14") carbocyclic group, (15") heterocyclic group, and (16") bicyclic carbocyclic group or heterocyclic group
 are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group
 wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl,
 (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein
 R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

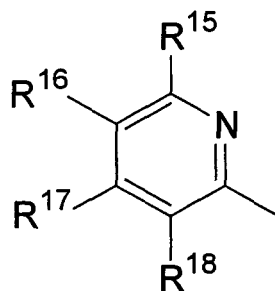
[0078] In formula (100), preferably, when Z represents -O-, R¹⁰³ represents a hydrogen atom.

[0079] In formula (100), preferably, R¹⁰⁴ and R¹⁰⁵ represent a hydrogen atom, a halogen atom, or C1-4 alkyl, more preferably a hydrogen atom, a halogen atom, or methyl, still more preferably a hydrogen atom.

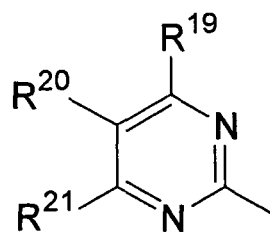
[0080] In formula (100), preferably, both R¹¹¹ and R¹¹² represent methyl, or alternatively R¹¹¹ represents a hydrogen atom while R¹¹² represents ethyl.

[0081] In formula (100), preferably, R¹¹⁴ represents a group of formula (a-4) or formula (a-5):

[Chemical formula 14]



(a-4)



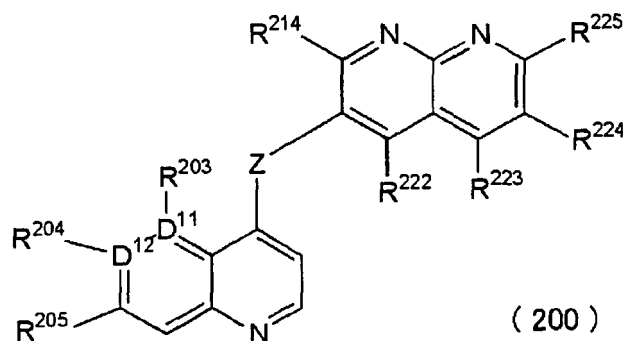
(a-5)

wherein

R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, represent a group selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, preferably selected from the group consisting of a hydrogen atom, a halogen atom, C1-2 alkyl, and C1-2 alkoxy, and, more preferably, all of R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.

[0082] In a preferred embodiment of the present invention, the compound of formula (I) may be a compound of formula (200):

[Chemical formula 15]



wherein

Z represents -O-, -NH-, -S-, or -C(=O)-, preferably -O- or -NH-, more preferably -O-,
 any one of D¹¹ and D¹² represents a nitrogen atom, and the other represents a carbon atom,
 R²⁰³ represents a hydrogen atom or a halogen atom, preferably a hydrogen atom,
 R²⁰⁴ and R²⁰⁵, which may be the same or different, represent

(1) a hydrogen atom ;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

(9) C1-6 alkoxy;

(12) -CO-OR^c;

(13) -CO-NR^dRe;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,
 wherein these groups are optionally substituted as defined in formula (I),

R²²² to R²²⁵, which may be the same or different, represent a group selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, preferably a group selected from the group consisting of a hydrogen atom, a halogen atom, and C1-4 alkyl, more preferably a hydrogen atom, a halogen atom, or methyl, still more preferably a hydrogen atom, and

R²¹⁴ represents

unsubstituted C1-4 alkyl,

an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group, or

an optionally substituted, bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group.

[0083] In formula (200), preferably, when Z represents -O- and, at the same time, R²⁰³ represents a hydrogen atom, all of R²²² to R²²⁵ represent a hydrogen atom.

[0084] In formula (200), preferably, R²⁰⁴ and R²⁰⁵ represent a hydrogen atom, a halogen atom, or C1-4 alkyl, more preferably a hydrogen atom, a halogen atom, or methyl, still more preferably a hydrogen atom.

[0085] In a preferred embodiment of the present invention, in formula (200), R²¹⁴ represents phenyl optionally substituted by hydroxyl, a halogen atom, amino group, C1-4 alkyl, or C1-4 alkoxy, more preferably phenyl optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy, still more preferably phenyl optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy, still more preferably unsubstituted phenyl.

[0086] In another preferred embodiment of the present invention, in formula (200), R²¹⁴ represents methyl or ethyl.

[0087] In still another embodiment of the present invention, in formula (I), when all of D¹ to D⁴ represent a carbon atom, requirement I) or II) should be satisfied:

I) any one of R⁴ and R⁵ represents (4) cyano group, (5) nitro group, (12) -CO-OR^c, (13) -CO-NR^dRe wherein any one of R^d and R^e represents optionally substituted C1-4 alkyl, (14) carbocyclic group, (15) heterocyclic group wherein the heterocyclic group contains at least one substituent, or (16) bicyclic carbocyclic or heterocyclic group; and

II) L represents a nitrogen atom, E, G, J, and M represent a carbon atom, R¹⁰ represents a hydrogen atom, and R¹⁴ represents (6) C1-6 alkyl group, (14) carbocyclic group, (15) heterocyclic group, or (16) bicyclic carbocyclic or heterocyclic group.

5 **[0088]** In another preferred embodiment of the present invention, in formula (I), when all of D¹ to D⁴ represent a carbon atom, at least one of R⁴ and R⁵ represents (4) cyano group, (5) nitro group, (12)-CO-OR^c, (14) carbocyclic group, (15) heterocyclic group containing at least one substituent, or (16) bicyclic carbocyclic or heterocyclic group.

[0089] In a further preferred embodiment of the present invention, in formula (I), when all of D¹ to D⁴ represent a carbon atom,

10 R¹ and R² represent a hydrogen atom, and

R⁴ and R⁵, which may be the same or different, represent a hydrogen atom, a halogen atom, or C1-4 alkyl, and

R⁴ and R⁵, which may be the same or different, represent

(4) cyano group;

15 (5) nitro group;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

wherein, in groups (12) and (13), R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, provided that at least one of R^d and R^e represents C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

20 (a) hydroxyl,
 (b) a halogen atom,
 (c) C1-4 alkoxy,
 25 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl,

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

30 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic group or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl,

35 (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and (15) heterocyclic group contains at least one substituent. In this case, more preferably, R⁴ and R⁵ represent

-CO-NR^dR^e wherein R^d and R^e, which may be the same or different, represent a hydrogen atom or C1-2 alkyl optionally substituted by hydroxyl, a halogen atom, phenyl, or amino group; or

40 phenyl optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0090] In another preferred embodiment of the present invention, in formula (I), when all of D¹ to D⁴ represent a carbon atom, at least one of R⁴ and R⁵ represents

45 an unsaturated five- or six-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl), or

a bicyclic unsaturated nine- or ten-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl.

[0091] In still another preferred embodiment of the present invention, in formula (I), when all of D¹ to D⁴ represent a carbon atom, R¹, R², R³, R⁴, R⁵, and R⁶ are as defined above. In this case, L represents a nitrogen atom, and E, G, J and M represent a carbon atom. Further, in this case, R¹⁴ represents (16) bicyclic carbocyclic or heterocyclic group in which these cyclic groups are optionally substituted as defined in formula (I).

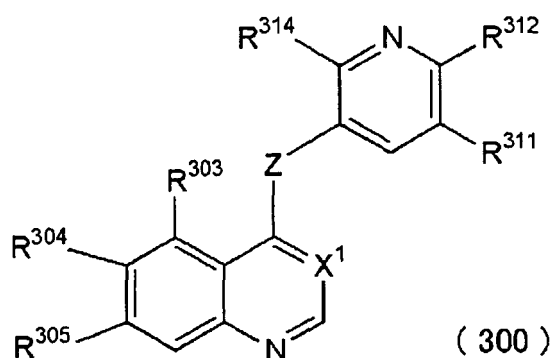
[0092] In a further preferred embodiment of the present invention, in formula (I), when all of D¹ to D⁴ represent a carbon atom, R¹, R², R³, R⁴, R⁵, and R⁶ are as defined above, L represents a nitrogen atom, and E, G, J and M represent a carbon atom. In this case, R¹⁴ represents

55 (6) C1-6 alkyl;
 wherein the alkyl group is optionally substituted as defined in formula (I),
 (14") a saturated or unsaturated five- or six-membered carbocyclic group;

(15ⁿ) a saturated or unsaturated five- or six-membered heterocyclic group; or
 (16ⁿ) a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;
 wherein (14ⁿ) carbocyclic group, (15ⁿ) heterocyclic group, and (16ⁿ) bicyclic carbocyclic group or heterocyclic group
 are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group
 wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl,
 (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein
 R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

[0093] In another preferred embodiment of the present invention, in formula (I), when both D¹ and D² represent a
 carbon atom, the compound of formula (I) may be a compound of formula (300):

[Chemical formula 16]



wherein

X¹ represents CH or N,

Z represents -O-, -NH-, -S-, or -C(=O)-, preferably -O- or -NH-, more preferably -O-,

R³⁰³ represents a hydrogen atom, a halogen atom, or C1-4 alkyl, preferably a hydrogen atom, a halogen atom, or methyl,
 more preferably a hydrogen atom,

R³⁰⁴ and R³⁰⁵, which may be the same or different, represent

(1) a hydrogen atom;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

(9) C1-6 alkoxy;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group;

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;

(17) -OCOR^k wherein R^k represents C1-4 alkyl; or

(18) -OSO₂R^l wherein R^l represents C1-4 alkyl,

wherein these groups are optionally substituted as defined in formula (I),

at least one of R³¹¹ and R³¹² represents C1-4 alkyl and the other represents a hydrogen atom or C1-4 alkyl, and
 R³¹⁴ represents an unsaturated six-membered heterocyclic group wherein the heterocyclic group is optionally sub-
 stituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two
 hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii)
 C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which
 may be the same or different, represent a hydrogen atom or C1-4 alkyl.

[0094] In formula (300), preferably, when Z represents -O-, R³⁰³ represents a hydrogen atom and R³¹⁴ represents a

group of formula (a-4) or formula (a-5). In this case, in formula (a-4) or formula (a-5), preferably, R¹⁵ to R¹⁸ and R¹⁹ to R²¹ are selected from the group consisting of a hydrogen atom, a halogen atom, methyl and methoxy.

[0095] In a preferred embodiment of the present invention, in formula (300),

Z represents -O-,

R³⁰³ represents a hydrogen atom, and

R³⁰⁴ represents

(1) a hydrogen atom;

(2) a halogen atom;

(3) hydroxyl;

(9) C1-6 alkoxy;

(17) -OCOR^k wherein R^k represents C1-4 alkyl; or

(18) -OSO₂R^L wherein R^L represents C1-4 alkyl,

wherein these groups are optionally substituted as defined in claim 1,

R³⁰⁵ represents a hydrogen atom, a halogen atom, or -CO-NH₂, and

R³¹⁴ represents a group of formula (a-4) or (a-5).

[0096] In formula (300), preferably, R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.

[0097] In formula (300), preferably, X¹ represents CH.

[0098] In formula (300), preferably, R³⁰⁴ represents C1-6 alkoxy which is optionally substituted as defined in claim 1, more preferably C1-6 alkoxy substituted by hydroxyl, still more preferably -O(CH₂)_{m1}-OH wherein m1 is an integer of 2 to 4. Still more preferably, R³⁰⁴ represents -OC₂H₅-OH.

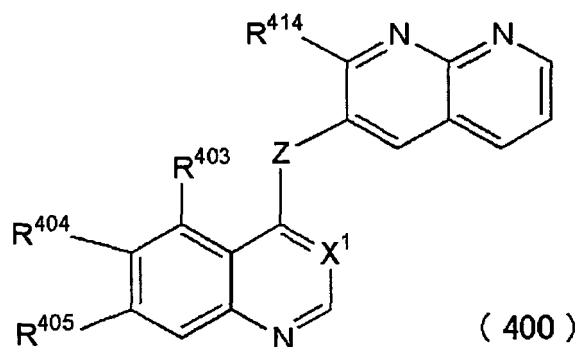
Preferably, R³⁰⁵ represents a hydrogen atom, a fluorine atom, or -CO-NH₂.

[0099] In formula (300), preferably, R³¹¹ and R³¹², which may be the same or different, represent C1-4 alkyl. More preferably, both R³¹¹ and R³¹² represent methyl. Alternatively, R³¹¹ represents a hydrogen atom and, at the same time, R³¹² represents C1-4 alkyl. Preferably, R³¹¹ represents a hydrogen atom, and, at the same time, R³¹² represents methyl or ethyl.

[0100] Preferred compounds of formula (300) are selected, for example, from compounds 181, 188, 192, 200, 202, and 205.

[0101] In another preferred embodiment of the present invention, in formula (I), when both D¹ and D² represent a carbon atom, the compound of formula (I) may be a compound of formula (400):

[Chemical formula 17]



wherein

X¹ represents CH or N,

Z represents -O-, -NH-, -S-, or -C(=O)-, preferably -O- or -NH-, more preferably -O-,

R⁴⁰³ represents a hydrogen atom, a halogen atom, or C1-4 alkyl, preferably a hydrogen atom, a halogen atom, or methyl, more preferably a hydrogen atom,

R⁴⁰⁴ and R⁴⁰⁵, which may be the same or different, represent

(1) a hydrogen atom;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

- (9) C1-6 alkoxy;
 (12) -CO-OR^c;
 (13) -CO-NR^dR^e;
 (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group;
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;
 (17) -OCOR^k wherein R^k represents C1-4 alkyl; or
 (18) -OSO₂R^l wherein R^l represents C1-4 alkyl,

wherein these groups are optionally substituted as defined in formula (I),

R⁴¹⁴ represents

- (6) C1-6 alkyl;

wherein the alkyl group is optionally substituted as defined in formula (I),

(14^{''}) a saturated or unsaturated five- or six-membered carbocyclic group;

(15^{''}) a saturated or unsaturated five- or six-membered heterocyclic group; or

(16^{''}) a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;

wherein (14^{''}) carbocyclic group, (15^{''}) heterocyclic group, and (16^{''}) bicyclic carbocyclic group or heterocyclic group

are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group

wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl,

(vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein

R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

[0102] In formula (400), preferably, when Z represents -O-, R⁴⁰³ represents a hydrogen atom, and

R⁴¹⁴ represents

an unsaturated five- or six-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group

is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl, or

a bicyclic unsaturated nine- or ten-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic

group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl. In this case, more

preferably, R⁴¹⁴ represents phenyl optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi')

alkyl, or (ix') C1-2 alkoxy.

[0103] In a preferred embodiment of the present invention, in formula (400),

X¹ represents CH,

Z represents -O-,

R⁴⁰³ represents a hydrogen atom,

any one of R⁴⁰⁴ and R⁴⁰⁵ represents C1-4 alkoxy substituted by hydroxyl, and the other represents unsubstituted C1-4

alkoxy, and

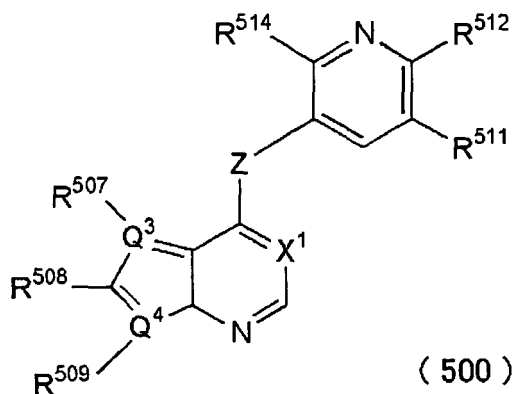
R⁴¹⁴ represents phenyl.

[0104] For example, compound 178 may be mentioned as preferred compounds of formula (400).

[0105] In a preferred embodiment of the present invention, the compound of formula (II) may be a compound of formula

(500):

[Chemical formula 18]



wherein

X¹ represents CH or N,

Z represents -O-, -NH-, -S-, or -C(=O)-, preferably -O- or -NH-, more preferably -O-,

any one of Q³ and Q⁴ represents a sulfur atom, and the other represents a carbon atom,

5 R⁵⁰⁷ to R⁵⁰⁹, which may be the same or different, represent

(1) a hydrogen atom;

(2) a halogen atom;

(3) hydroxyl;

10 (6) C1-6 alkyl;

(9) C1-6 alkoxy;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

15 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group

wherein these groups are optionally substituted as defined in formula (II),

R⁵¹¹ and R⁵¹², which may be the same or different, are selected from the group consisting of a hydrogen atom and

C1-4 alkyl, preferably selected from the group consisting of a hydrogen atom, methyl, and ethyl,

20 R⁵¹⁴ represents

(14") a saturated or unsaturated five- or six-membered carbocyclic group;

(15") a saturated or unsaturated five- or six-membered heterocyclic group; or

(16") a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;

wherein (14") carbocyclic group, (15") heterocyclic group, and (16") bicyclic carbocyclic group or heterocyclic group

25 are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group

wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl,

(vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein

R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

30 **[0106]** In formula (500), preferably,

when Q³ represents a sulfur atom, Q⁴ represents a carbon atom, or

when Q³ represents a carbon atom, Q⁴ represents a sulfur atom.

[0107] In formula (500), both R⁵¹¹ and R⁵¹² represent methyl, or alternatively, R⁵¹¹ represents a hydrogen atom while R⁵¹² represents ethyl. In this case, preferably, Z represents -O-.

35 **[0108]** In formula (500), preferably, R⁵¹⁴ represents a group of formula (a-4) or formula (a-5). In formula (a-4) or formula (a-5), R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy. Preferably, all of R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.

[0109] Preferably, R⁵⁰⁷ and R⁵⁰⁹ represent a hydrogen atom, a halogen atom, or C1-4 alkyl, more preferably a hydrogen atom, a halogen atom, or methyl, still more preferably a hydrogen atom.

40 **[0110]** Preferably, R⁵⁰⁸ represents

a hydrogen atom,

a halogen atom,

C1-4 alkyl, or

45 a saturated or unsaturated six-membered carbocyclic or,

a saturated or unsaturated six-membered heterocyclic group,

wherein said carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0111] In formula (500), preferably,

50 R⁵⁰⁷ and R⁵⁰⁹ represent a hydrogen atom, a halogen atom, or C1-4 alkyl, and, in this case,

R⁵⁰⁸ represents

a hydrogen atom,

a halogen atom,

C1-4 alkyl,

55 a saturated or unsaturated six-membered carbocyclic group, or

a saturated or unsaturated six-membered heterocyclic group

wherein the carbocyclic and heterocyclic groups are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0112] In a preferred embodiment of the present invention, in formula (500),

Q³ represents a sulfur atom,

Q⁴ represents a carbon atom,

R⁵⁰⁸ represents

a hydrogen atom,

C1-4 alkyl, or

a saturated or unsaturated six-membered carbocyclic or heterocyclic group,

wherein said carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy, and

R⁵⁰⁹ represents a hydrogen atom. In this case, more preferably, R⁵⁰⁸ represents a hydrogen atom or phenyl.

[0113] In a preferred embodiment of the present invention, in formula (500),

Q³ represents a carbon atom,

Q⁴ represents a sulfur atom, and

R⁵⁰⁷ and R⁵⁰⁸ are selected from the group consisting of a hydrogen atom and C1-4 alkyl. In this case, more preferably,

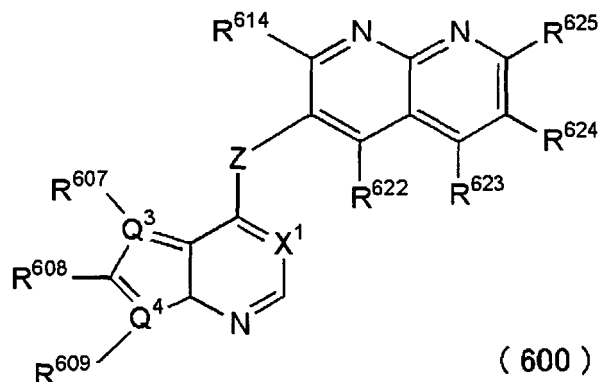
both R⁵⁰⁷ and R⁵⁰⁸ represent a hydrogen atom or

both R⁵⁰⁷ and R⁵⁰⁸ represent methyl or

R⁵⁰⁷ represents methyl while R⁵⁰⁸ represents a hydrogen atom.

[0114] In a preferred embodiment of the present invention, the compound of formula (II) may be a compound of formula (600):

[Chemical formula 19]



wherein

X¹ represents CH or N,

Z represents -O-, -NH-, -S-, or -C(=O)-,

any one of Q³ and Q⁴ represents a sulfur atom, and the other represents a carbon atom,

R⁶⁰⁷ to R⁶⁰⁹, which may be the same or different, represent

(1) a hydrogen atom;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

(9) C1-6 alkoxy;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,

wherein these groups are optionally substituted as defined in formula (II),

R⁶²² to R⁶²⁵, which may be the same or different, are selected from the group consisting of a hydrogen atom, a

halogen atom, C1-4 alkyl, and C1-4 alkoxy, and

R⁶¹⁴ represents

unsubstituted C1-4 alkyl,

an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group, or

an optionally substituted bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group.

[0115] In formula (600), preferably,
when Q³ represents a sulfur atom, Q⁴ represents a carbon atom, or
when Q³ represents a carbon atom, Q⁴ represents a sulfur atom.

[0116] In formula (600), when Z represents -O-, preferably, all of R⁶²² to R⁶²⁵ represent a hydrogen atom.

[0117] In a preferred embodiment of the present invention, in formula (600), R⁶¹⁴ represents phenyl optionally substituted by hydroxyl, a halogen atom, amino group, C1-4 alkyl, or C1-4 alkoxy, more preferably phenyl optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy, still more preferably unsubstituted phenyl.

[0118] In another preferred embodiment of the present invention, in formula (600), R⁶¹⁴ represents methyl or ethyl.

[0119] Preferably, R⁶⁰⁷ and R⁶⁰⁹ represent a hydrogen atom, a halogen atom, or C1-4 alkyl, more preferably a hydrogen atom, a halogen atom, or methyl, more preferably a hydrogen atom.

[0120] Preferably, R⁶⁰⁸ represents

a hydrogen atom,

a halogen atom,

C1-4 alkyl,

a saturated or unsaturated six-membered carbocyclic group, or

a saturated or unsaturated six-membered heterocyclic group,

wherein the carbocyclic and heterocyclic groups are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0121] In formula (600), preferably, R⁶⁰⁷ and R⁶⁰⁹ represent a hydrogen atom, a halogen atom, or C1-4 alkyl

R⁶⁰⁸ represents

a hydrogen atom,

a halogen atom,

C1-4 alkyl,

a saturated or unsaturated six-membered carbocyclic group, or

a saturated or unsaturated six-membered heterocyclic group,

wherein the carbocyclic and heterocyclic groups are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy.

[0122] In a preferred embodiment of the present invention, in formula (600),

Q³ represents a sulfur atom,

Q⁴ represents a carbon atom,

R⁶⁰⁸ represents

a hydrogen atom,

C1-4 alkyl, or

a saturated or unsaturated six-membered carbocyclic or heterocyclic group,

wherein said carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy, and

R⁶⁰⁹ represents a hydrogen atom. In this case, more preferably, R⁶⁰⁸ represents a hydrogen atom or phenyl.

[0123] In a preferred embodiment of the present invention, in formula (600),

Q³ represents a carbon atom,

Q⁴ represents a sulfur atom, and

R⁶⁰⁷ and R⁶⁰⁸ are selected from the group consisting of a hydrogen atom and C1-4 alkyl. In this case, more preferably,

both R⁶⁰⁷ and R⁶⁰⁸ represent a hydrogen atom or

both R⁶⁰⁷ and R⁶⁰⁸ represent methyl or

R⁶⁰⁷ represents methyl while R⁶⁰⁸ represents a hydrogen atom.

[0124] More preferred compounds of the present invention include compounds described in Examples.

When the compounds of the present invention are compounds of formula (I), the compounds are preferably selected from the group consisting of compounds 1 to 27, 30, 31, 37 to 70, 73, 74, 81 to 179 and 181 to 225, more preferably compounds 1, 4, 6, 13, 16, 18, 27, 30, 37, 49, 50, 51, 56, 66, 103, 110, 117, 126, 133, 140 to 145, 155, 158, 159, 161, 162, 174 to 178, 181, 188, 192, 200, 202 and 205, still more preferably compounds 37, 142, 178, 181, 188, 192, 200, 202 and 205.

When the compounds of the present invention are compounds of formula (II), the compounds are preferably selected from the group consisting of compounds 28, 29, 32 to 35, 71, 72, 75 to 78 and 180, more preferably compounds 28, 32 and 33.

Salts or solvates of compounds

[0125] The compounds according to the present invention may form pharmaceutically acceptable salts thereof. Preferred examples of such salts include: alkali metal or alkaline earth metal salts such as sodium salts, potassium salts or calcium salts; hydrohalogenic acid salts such as hydrofluoride salts, hydrochloride salts, hydrobromide salts, or hydroiodide salts; inorganic acid salts such as nitric acid salts, perchloric acid salts, sulfuric acid salts, or phosphoric acid salts; lower alkylsulfonic acid salts such as methanesulfonic acid salts, trifluoromethanesulfonic acid salts, or ethanesulfonic acid salts; arylsulfonic acid salts such as benzenesulfonic acid salts or p-toluenesulfonic acid salts; organic acid salts such as fumaric acid salts, succinic acid salts, citric acid salts, tartaric acid salts, oxalic acid salts, maleic acid salts, acetic acid salts, malic acid salts, lactic acid salts, or ascorbic acid salts; and amino acid salts such as glycine salts, phenylalanine salts, glutamic acid salts, or aspartic acid salts.

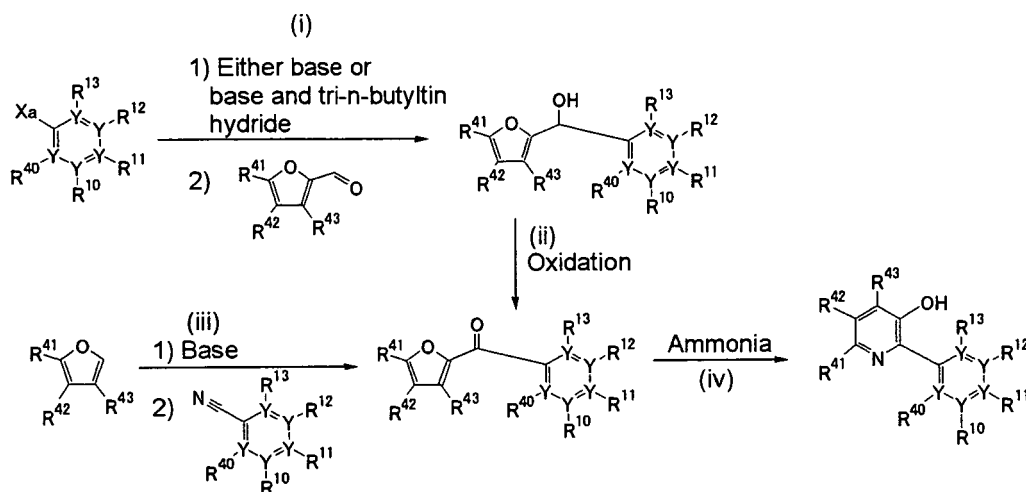
The compounds according to the present invention may form solvates. Such solvates include, for example, hydrates, alcoholates, for example, methanolates and ethanolates, and etherates, for example, diethyl etherates.

Production of compounds according to the present invention

[0126] The compounds according to the present invention can be produced, for example, according to schemes 1 to 19. Quinoline derivatives or quinazoline derivatives of Reference Examples having structures similar to the compounds according to the present invention can be produced, for example, according to schemes r1 to r34 which will be described later. Further, the compounds according to the present invention may also be synthesized by conventional methods described, for example, in WO 2000/43366 and WO 2004/018430. In the present invention, starting compounds necessary for the synthesis of the compounds according to the present invention are commercially available or alternatively can be easily produced by conventional methods.

Scheme 1

[0127] Bipyridine derivatives as a partial structure of the compounds according to the present invention can be produced, for example, according to scheme 1.

[Chemical formula 20]

wherein

R^{10} to R^{13} are as defined above,

R^{40} and Xa are selected from groups as defined in R^{10} , and

R^{41} to R^{43} are selected from groups as defined in R^{15} , and

Y 's each independently represent C or N.

[0128] In this scheme, the aimed compounds can be synthesized through the following two routes:

(I) A ketone derivative can be produced by reacting an allyl halogen derivative with a base, for example, n-butyllithium,

either directly or after conversion to a trialkyltin compound, for example, using tri-n-butyltin hydride, reacting the resultant compound with a furfural derivative (step (i)) to give an alcohol derivative, and then oxidizing the alcohol derivative with a suitable oxidizing agent, for example, manganese dioxide (step (ii)).

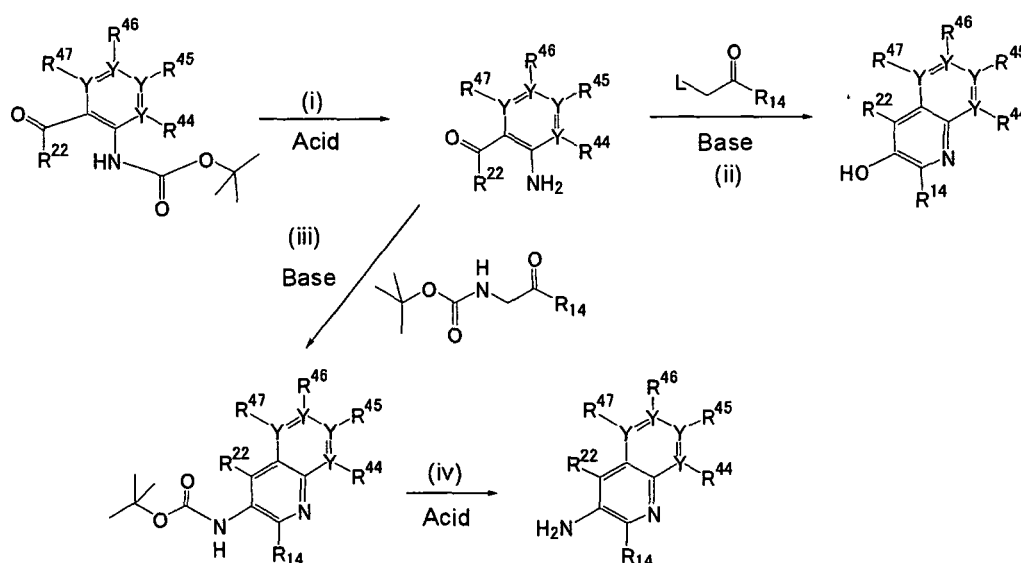
(II) A ketone derivative can be produced by reacting a furan derivative with an alkyllithium reagent, for example, n-butyllithium, and then reacting the resultant compound with an acylating agent (step (iii)).

The aimed compounds can be produced by reacting the ketone derivative produced in the above step (I) or (II) with ammonia (step (iv)).

Scheme 2

[0129] Naphthyridine derivatives as a partial structure of the compounds according to the present invention can be produced, for example, according to scheme 2.

[Chemical formula 21]



wherein

R¹⁴ and R²² are as defined above,

R⁴⁴ to R⁴⁷ are selected from groups defined in R²³, and

Y's each independently represent C or N.

[0130] The aimed 3-hydroxypyridine derivatives can be produced by deprotecting an aniline derivative in which the amino group has been protected (step (i)), and reacting the resultant o-acylaniline derivative with a methyl ketone derivative (step (ii)).

The aimed 3-aminopyridine derivatives can be produced by reacting the o-acylaniline derivative produced above with an aminomethyl ketone derivative in which the amino group has been protected (step (iii)), and then deprotecting the resultant compound, that is, removing the amino group from the resultant compound (step (iv)).

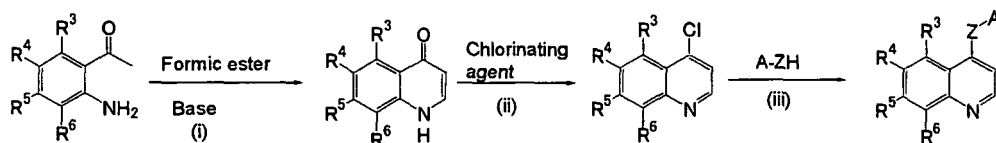
Schemes 3 and 4

[0131] The quinoline derivatives according to the present invention can be produced, for example, according to scheme 3 or 4.

Scheme 3:

[0132]

[Chemical formula 22]



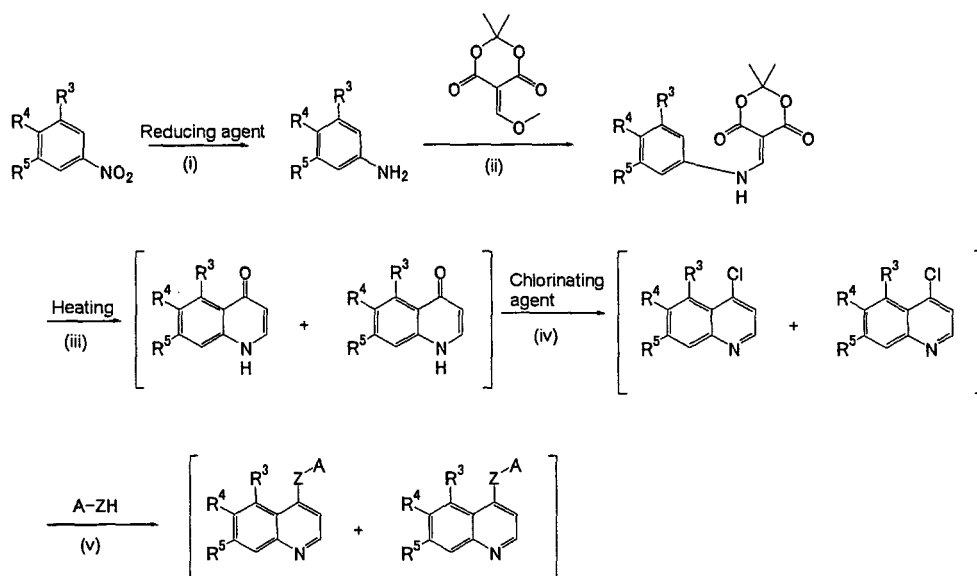
wherein the substituents are as defined above.

10 **[0133]** In scheme 3, the quinolone derivatives as an intermediate can be synthesized, for example, according to WO 97/17329. The 4-chloroquinolone derivatives can be synthesized by a conventional method described, for example, in Org. Synth. Col. Vol.3, 272 (1955), Acta Chim. Hung., 112, 241 (1983), or WO 98/47873. The aimed compounds can be synthesized by reacting the resultant 4-chloroquinolone derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a system free from a solvent in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (iii)).

Scheme 4:

20 **[0134]**

[Chemical formula 23]



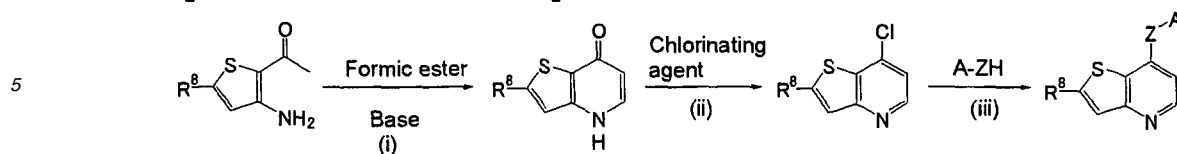
45 wherein the substituents are as defined above.

[0135] In scheme 4, the 4-chloroquinolone derivatives as an intermediate can be synthesized by a conventional method described, for example, in WO 00/50405. The aimed compounds can be synthesized by reacting the resultant 4-chloroquinolone derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a system free from a solvent in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (v)).

Scheme 5

55 **[0136]** The thiazopyridine derivatives according to the present invention can be produced, for example, according to scheme 5.

[Chemical formula 24]



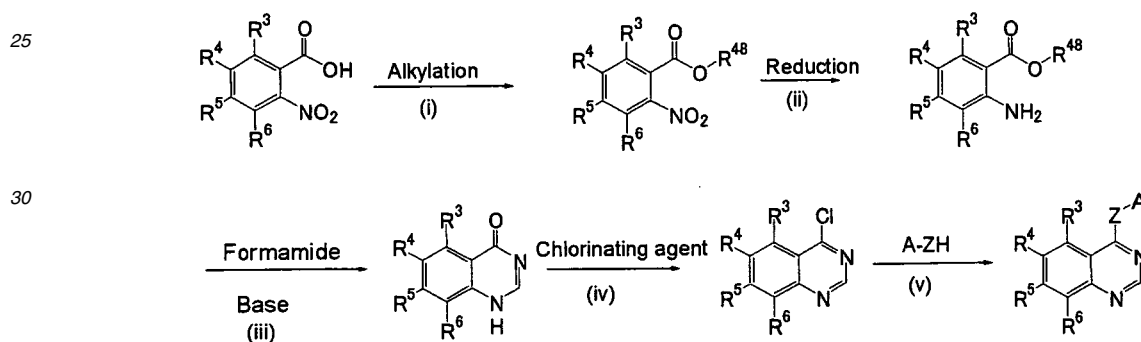
wherein the substituents are as defined above.

[0137] The aimed compounds can be synthesized by reacting an acetyl-amino-thiophene derivative with a formic ester in the presence of a suitable base, for example, sodium methoxide (step (i)), reacting the resultant thienopyridin-7-one derivative with a suitable chlorinating agent, for example, phosphorus oxychloride (step (ii)), and reacting the resultant 7-chlorothienopyridine derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (iii)).

Scheme 6

[0138] The quinazoline derivatives according to the present invention can be produced, for example, according to scheme 6.

[Chemical formula 25]



wherein

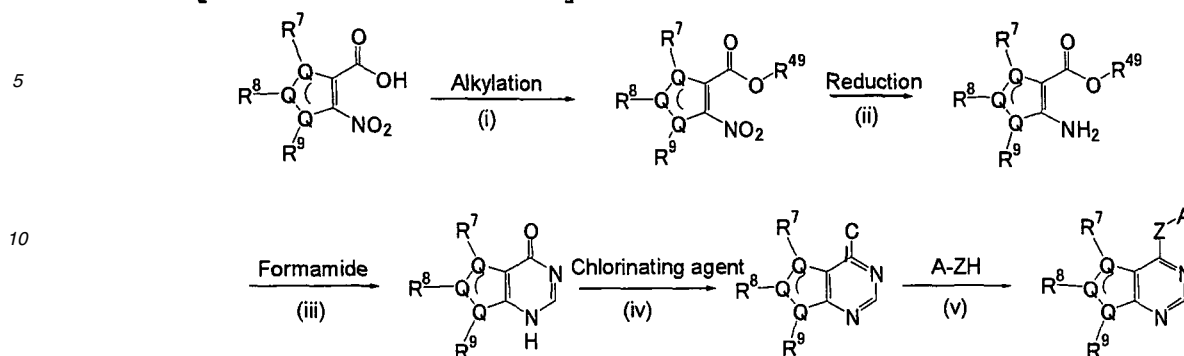
R^{48} represents a group suitable for the cyclization reaction in step (iii), and the other substituents are as defined above.

[0139] The 4-chloroquinazoline derivatives can be synthesized by a conventional method described, for example, in J. Am. Chem. Soc., 68, 1299 (1946), J. Am. Chem. Soc., 68, 1305 (1946), and Dai Yuki Kagaku (Comprehensive Organic Chemistry), Editor, Kotake, Vol. 17, p. 150, Asakura Publishing Co., Ltd. (published in 1967). The aimed compounds can be synthesized by reacting the resultant 4-chloroquinazolinone derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system, in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (v)).

Scheme 7

[0140] The heterocondensed ring-type pyrimidine derivatives according to the present invention can be produced, for example, according to scheme 7.

[Chemical formula 26]



wherein

R⁴⁹ represents a group suitable for the cyclization reaction in step (iii),
 Q's each independently represent C, S, or N, and
 the other substituents are as defined above.

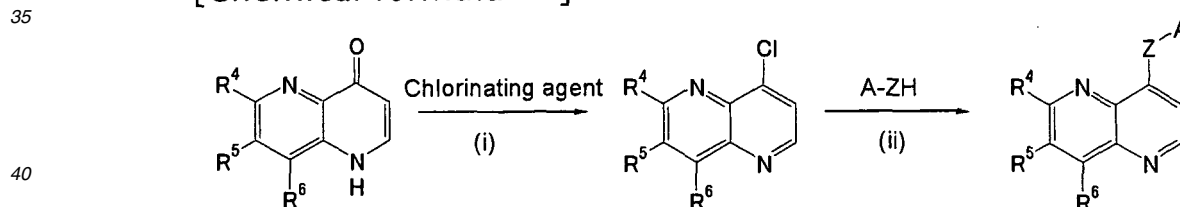
20 **[0141]** The aimed compounds can be produced by reacting an o-nitrocarboxylic acid derivative with a suitable alkylating agent, for example, methyl iodide (step (i)), reducing the nitro group in the resultant compound with a suitable reducing agent, for example, palladium hydroxide/a hydrogen gas) (step (ii)) to give an o-aminocarboxylic ester, reacting the o-aminocarboxylic ester with formamide (step (iii)), reacting the resultant compound with a suitable chlorinating agent, for example, phosphorus oxychloride (step (iv)), and reacting the resultant chloropyrimidine derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (v)).

25

Scheme 8

30 **[0142]** The 1,5-naphthyridine derivatives according to the present invention can be produced, for example, according to scheme 9.

[Chemical formula 27]



wherein the substituents are as defined above.

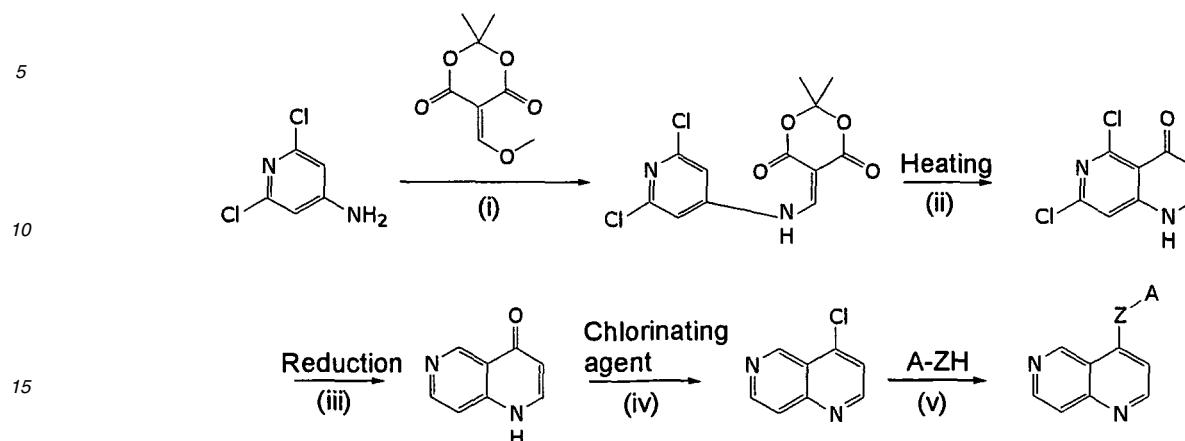
45 **[0143]** The 4-naphthyridinone derivatives can be synthesized in the same manner as shown, for example, in scheme 3 or 4. The aimed compounds can be synthesized by reacting the 4-naphthyridinone derivative with a suitable chlorinating agent, for example, phosphorus oxychloride (step (i)), and reacting the resultant chloronaphthyridine derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (ii)).

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Scheme 9

55 **[0144]** The 1,6-naphthyridine derivatives according to the present invention can be produced, for example, according to scheme 9.

[Chemical formula 28]



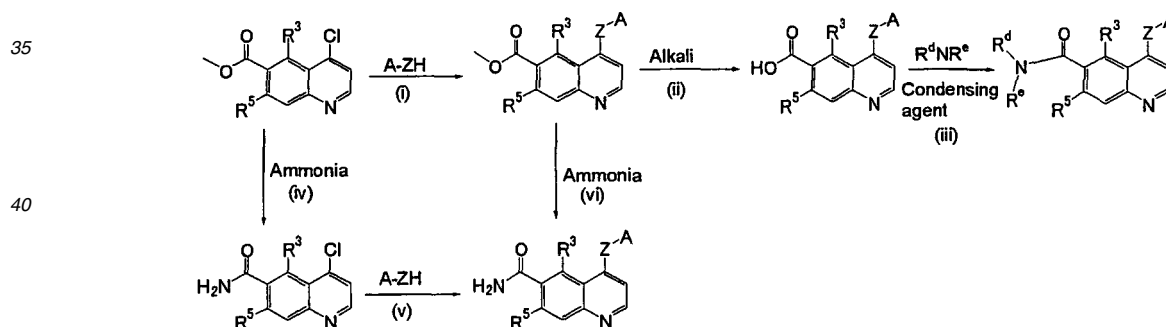
20 [0145] The aimed compounds can be synthesized by reacting an 4-amino-2,6-dichloropyridine with 5-methoxymethylene-2,2-dimethyl-1,3-dioxan-4,6-dione (step (i)), further heating the mixture, for example, at 220°C for one hr (step (ii)), reducing the resultant compound with a suitable reducing agent, for example, palladium hydroxide/a hydrogen gas (step (iii)) to give a [1,6]naphthyridinone derivative, reacting the [1,6]naphthyridinone derivative with a suitable chlorinating agent, for example, phosphorus oxychloride (step (i)), and reacting the resultant chloronaphthyridine derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (ii)).

25

Scheme 10

30 [0146] The 6-amidoquinoline derivatives according to the present invention can be produced, for example, according to scheme 10.

[Chemical formula 29]



wherein the substituents are as defined above.

50 [0147] The N-monosubstituted or N-disubstituted amide derivatives can be produced by reacting the quinoline-6-carboxylic ester derivative produced according to scheme 3 or 4 with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (i)), subjecting the resultant compound to ester hydrolysis with a suitable alkali reagent, for example, lithium hydroxide (step (ii)), and condensing the resultant carboxylic acid derivative with an amine using a suitable condensing agent, for example, 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride and 1-hydroxybenzotriazole hydrate (step (iii)).

55 [0148] The N-unsubstituted amide derivatives can be synthesized through the following two routes.

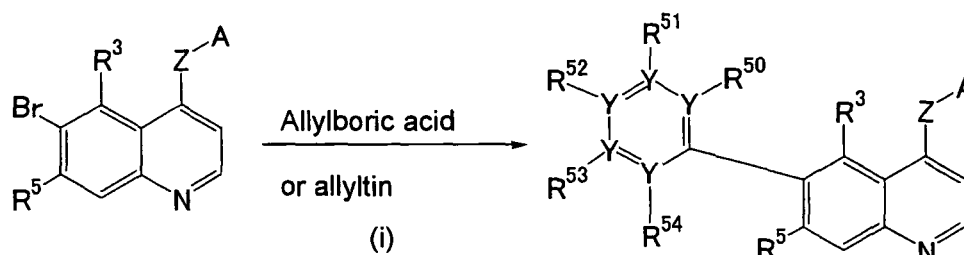
- (I) The aimed compounds can be synthesized by reacting the compound produced in step (i) with ammonia (step (vi)).
- (II) The aimed compounds can be synthesized by reacting the quinoline-6-carboxylic ester derivative with ammonia (step (iv)) and reacting the resultant compound with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative (step (ii)).

ridine derivative (step (v)) in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system, in the presence of a suitable base, for example, 4-dimethylaminopyridine.

Scheme 11

[0149] The 6-phenylquinoline derivatives according to the present invention can be produced, for example, according to scheme 11.

[Chemical formula 30]



wherein

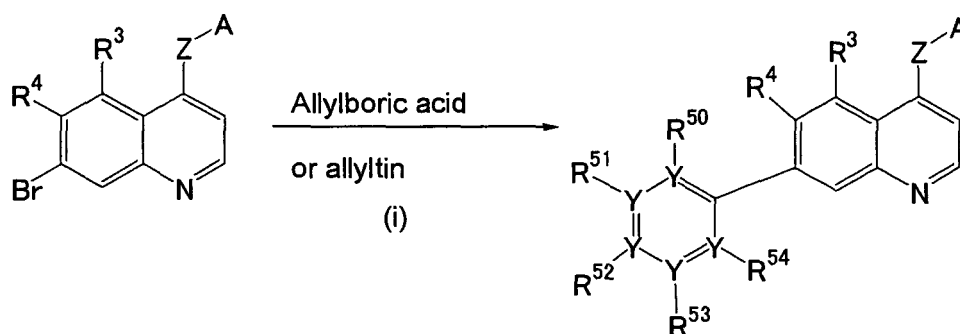
R⁵⁰ to R⁵³ represent (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the other substituents are as defined above.

[0150] The aimed compounds can be produced by reacting the 6-bromoquinoline derivative produced according to scheme 3 or 4 with an allyltin reagent or an allylboric acid reagent in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenylphosphine) palladium (step (i)).

Scheme 12

[0151] The 7-phenylquinoline derivatives according to the present invention can be produced, for example, according to scheme 12.

[Chemical formula 31]



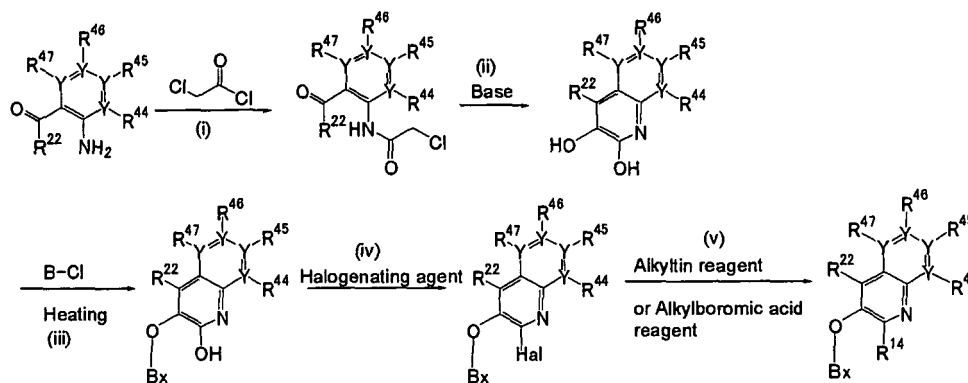
wherein the substituents are as defined above.

[0152] The aimed compounds can be produced by reacting the 7-bromoquinoline derivative produced according to scheme 3 or 4 with an allyltin reagent or an allylboric acid reagent in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenylphosphine) palladium (step (i)).

Scheme 13

[0153] The 2-heteroring-naphthyridine derivatives according to the present invention can be produced, for example, according to scheme 13.

[Chemical formula 32]



wherein

Hal represents a halogen atom,

Bx represents the compound produced in schemes 3 to 10, and

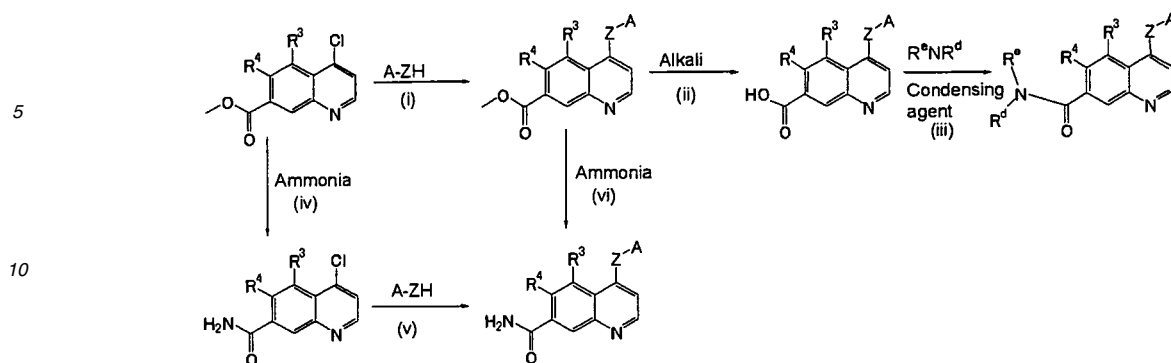
the other substituents are as defined above.

[0154] The aimed compounds can be produced by reacting an aniline derivative with chloroacetyl chloride (step (i)), then reacting the resultant amide derivative with a suitable base, for example, an aqueous potassium hydroxide solution (step (ii)) to give a 2,3-dihydroxyquinoline derivative, reacting the 2,3-dihydroxyquinoline derivative with the compound produced according to schemes 3 to 10 in a suitable solvent, for example, o-dichlorobenzene, or in a solvent-free system (step (iii)) to give a 2-hydroxyquinoline derivative, reacting the 2-hydroxyquinoline derivative with a suitable halogenating agent, for example, tetrabutylammonium bromide (step (iv)) to give a 2-haloquinoline derivative, and reacting the 2-haloquinoline derivative with an alkyltin reagent or an alkylboronic acid reagent in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenyl)phosphine palladium (step (v)).

Scheme 14

[0155] The 7-amidoquinoline derivatives according to the present invention can be produced, for example, according to scheme 14.

[Chemical formula 33]



15 wherein the substituents are as defined above.]

[0156] The N-monosubstituted or N-disubstituted amide derivatives can be produced by reacting the quinoline-7-carboxylic ester derivative produced according to scheme 3 or 4 with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system in the presence of a suitable base, for example, 4-dimethylaminopyridine (step (i)), subjecting the resultant compound to ester hydrolysis with a suitable alkali reagent, for example, lithium hydroxide (step (ii)), and condensing the resultant carboxylic acid derivative with an amine using a suitable condensing agent, for example, 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride and 1-hydroxybenzotriazole hydrate (step (iii)).

[0157] The N-unsubstituted amide derivatives can be synthesized through the following two routes.

- 25 (I) The aimed compounds can be synthesized by reacting the compound produced in step (i) with ammonia (step (vi)).
 (II) The aimed compounds can be synthesized by reacting the quinoline-7-carboxylic ester derivative with ammonia (step (iv)) and reacting the resultant compound with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative (step (v)) in a suitable solvent, for example, 1,2-dichlorobenzene, or in a solvent-free system, in the presence of a suitable base, for example, 4-dimethylaminopyridine.

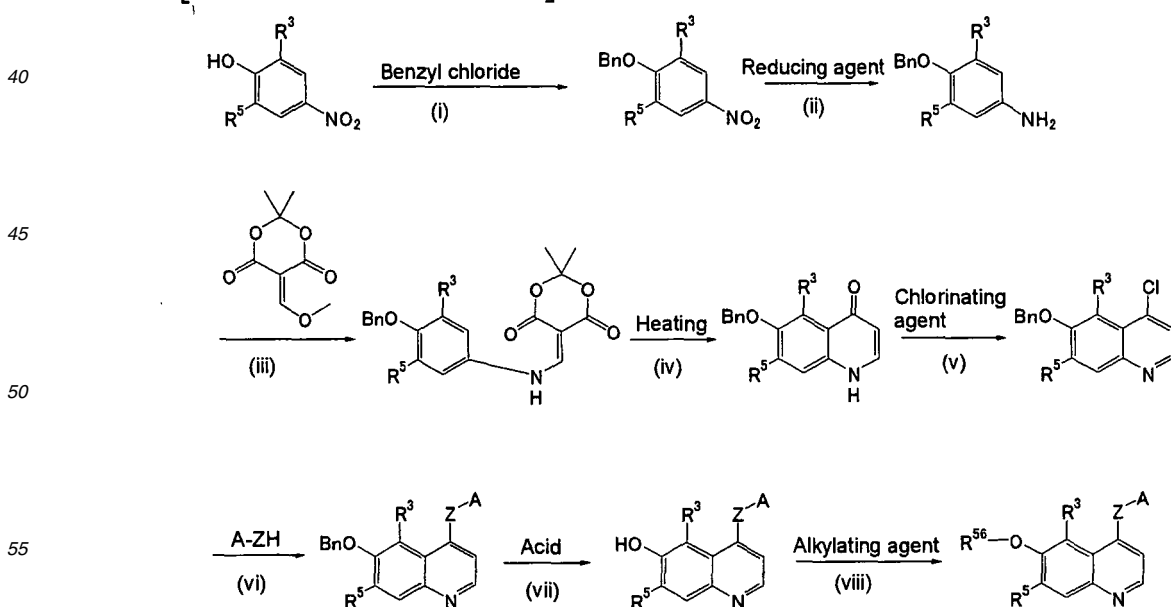
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Scheme 15

[0158] The 6-alkoxyquinoline derivatives or 7-alkoxyquinoline derivatives according to the present invention can be produced, for example, according to scheme 15.

35

[Chemical formula 34]



wherein

R⁵⁶ represents a substituent that can be selected when -OR⁵⁶ is provided in the definition of R⁴, and the other substituents are as defined above.

[0159] The aimed 6-alkoxyquinoline derivatives can be produced by reacting a 4-nitrophenol derivative with benzyl chloride in a suitable solvent, for example, N,N-dimethylformamide, in the presence of a suitable base, for example, potassium carbonate (step (i)), treating the resultant compound in the same manner as shown in scheme 4 (steps (ii) to (vi)) to give a 6-benzyloxyquinoline derivative, treating the resultant 6-benzyloxyquinoline derivative with a suitable acid, for example, methanesulfonic acid/trifluoroacetic acid (step (vii)) to remove the benzyl group for deprotection, and reacting the phenol compound thus obtained with an alkylating agent in a suitable solvent, for example, N,N-dimethylformamide, in the presence of a suitable base, for example, potassium carbonate (step (viii)).

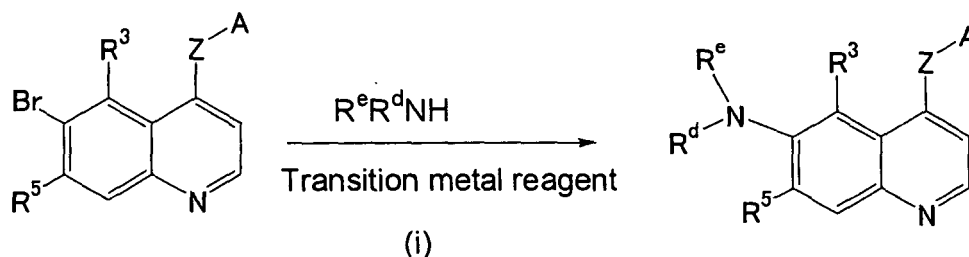
The aimed 7-alkoxyquinoline derivatives can be produced via the same steps as described above, except that a 3-nitrophenol derivative is used as the starting compound.

This scheme was described taking 6-alkoxyquinoline derivatives as an example. However, 7-alkoxyquinoline derivatives can also be produced likewise.

Scheme 16

[0160] The 6-alkylamine derivatives according to the present invention can be produced, for example, according to scheme 16.

[Chemical formula 35]



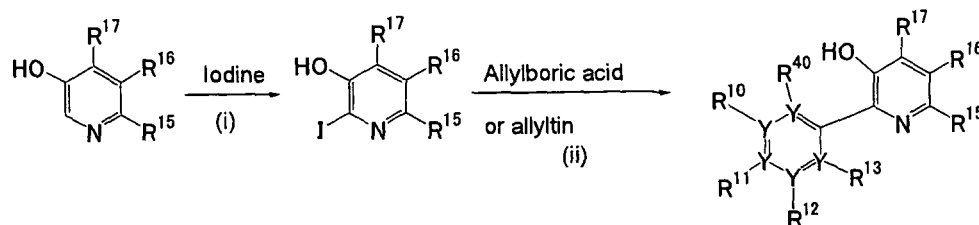
wherein the substituents are as defined above.

[0161] The aimed compounds can be produced by reacting the 6-bromoquinoline derivative produced according to scheme 3 or 4 with an alkylamine in the presence of a suitable transition metal catalyst, for example, palladium acetate, and a suitable base, for example, cesium carbonate (step (i)).

Scheme 17

[0162] The bipyridine derivatives as a partial structure of the compounds according to the present invention can be produced, for example, according to scheme 17.

[Chemical formula 36]



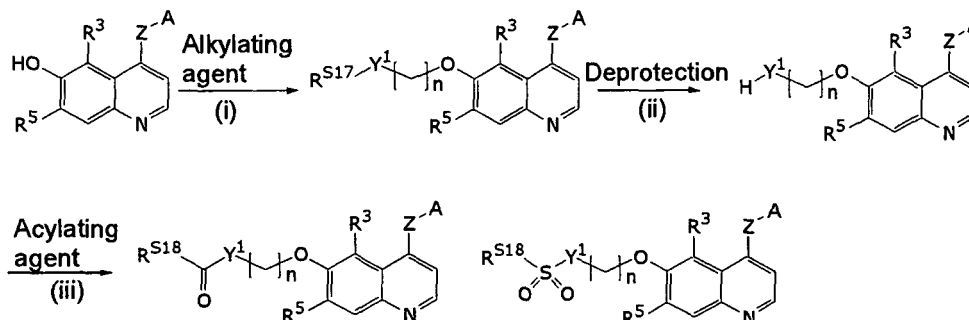
wherein the substituents are as defined above.

[0163] The aimed compounds can be produced by reacting a 3-hydroxypyridine derivative with iodine in a suitable solvent, for example, methanol/water (step (i)) and then reacting the resultant compound with an allyltin reagent or an allylboric acid reagent in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenyl)phosphine palladium (step (ii)).

Scheme 18

[0164] The quinoline derivatives substituted at the 6-position by amide or by an ester derivative according to the present invention can be produced, for example, according to scheme 18.

[Chemical formula 37]



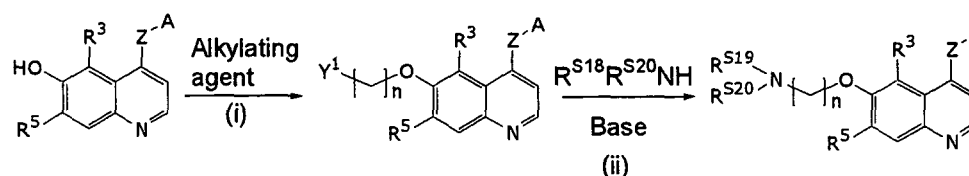
wherein the substituents are as defined above; Y^1 represents N or CH; and R^{S17} and R^{S18} represent C1-6 alkyl optionally substituted by amino.

The aimed compounds can be produced by reacting a quinolin-6-ol derivative with an alkylating agent having a protected functional group, for example, n-(2-bromoethyl)phthalimide, in the presence of a base, for example, potassium carbonate (step (i)), deprotecting the resultant compound under suitable conditions, for example, with hydrazine (step (ii)), and reacting the produced functional group with an acylating agent, for example, acetic anhydride, in the presence of a suitable base, for example, triethylamine (step (iii)).

Scheme 19

[0165] The derivatives having alkylamine at the 6-position according to the present invention can be produced, for example, according to scheme 19.

[Chemical formula 38]



wherein the substituents are as defined above and R^{S19} and R^{S20} represent C1-4 alkyl or phenyl.

The aimed compounds can be produced by reacting a quinolin-6-ol derivative with an alkyl dihalide, for example, 1-bromo-2-chloro-ethane, in the presence of a base, for example, potassium carbonate (step (i)) and reacting the resultant compound with an amine in the presence of a suitable base, for example, potassium carbonate (step (ii)).

Use of compounds/pharmaceutical composition

[0166] The compounds according to the present invention can inhibit the action of $TGF\beta$ on cells in vitro (see Test Example 1A).

Likewise, the quinoline derivatives or quinazoline derivatives of Reference Examples (that is, compounds r1 to r469) having structures close to the compounds according to the present invention can also inhibit the action of $TGF\beta$ on cells in vitro (see Test Example 1B). Therefore, a person having ordinary skill in the art could easily understand that naphthyridine derivatives, thienopyridine derivatives, and thienopyrimidine derivatives (falling within the scope of the present invention), which have the same substituents as the quinoline derivatives or quinazoline derivatives of Reference Examples and are different from the quinoline derivatives or quinazoline derivatives of Reference Examples only in the ring structure of the mother nucleus, can also inhibit the action of $TGF\beta$ on cells in vitro.

[0167] As described in the column of BACKGROUND ART, the inhibition of $TGF\beta$ has been regarded as effective for

the prevention or treatment of all of diseases involving the fibrosis including chronic renal diseases. Examples of documents showing the correlation between TGF β and these diseases are as described in the column of BACKGROUND ART.

5 [0168] The compounds according to the present invention actually exhibited anti-fibrotic activity in vivo (see Test Example 7).

Further, the quinoline derivatives or quinazoline derivatives of the Reference Examples actually exhibited anti-fibrotic activity in vivo (see Test Examples 2 to 4). Accordingly, it would be apparent, from these Test Examples, to a person having ordinary skill in the art that the compounds according to the present invention can be used for the prevention or treatment of diseases for which TGF β inhibition is effective therapeutically.

10 [0169] Furthermore, the compounds according to the present invention actually suppressed cell growth inhibitory action in a test using A549 cells (Test Example 6). Furthermore, the compounds according to the present invention actually suppressed BMP signal inhibitory action in vitro (Test Example 7).

15 [0170] It was found that some of the compounds according to the present invention are superior to the conventional compounds having TGF- β inhibitory activity in an improvement in pharmacokinetic profile, an improvement in selectivity for various kinases, or a reduction in cell growth inhibitory activity. For example, the selectivity for BMP signals is included in the selectivity for various kinases. BMP signals are deeply involved in the differentiation of osteoblasts, and it has recently been suggested that the genetic mutation of receptors (ALK1 and BMP type II receptors) related to the signals is deeply involved in the onset of hereditary hemorrhagic telangiectasia and primary pulmonary hypertension (J Soc Biol. 2002; 196(1): 53-8). Further, compounds, which strongly inhibit cell growth, are considered to be related directly to the development of toxicity in individuals. For example, compounds 178, 179, 181, 182, 184, 186, 187, 192, 194, 200 to 202, 204 to 206, 217, 222 and 225 may be mentioned as compounds for which the above improvement has been made.

20 [0171] More specifically, compounds 179, 181, 182, 184, 186, 187 and 205 had reduced inhibitory activity against cell growth or BMP4 signals as compared with Example 261 or Example 269 described in WO 03/00660. Likewise, compounds 192, 194, 200, 201, 202, 204, 206, 217, 222 and 225 had reduced inhibitory activity against cell growth of A549 cells and reduced inhibitory activity against BMP4 signals as compared with Example 274 described in WO 03/00660.

25 [0172] Accordingly, the compounds according to the present invention can be used for the prevention or treatment of diseases for which TGF β inhibition is effective therapeutically. Further, the compounds according to the present invention can be used for ex vivo expansion of cells.

30 [0173] The term "TGF β inhibition" as used herein means the inhibition of the intracellular or tissue activity of TGF β , a kind of cytokine.

According to the present invention, there is provided a method for preventing or treating a disease for which TGF β inhibition is effective therapeutically or prophylactically, said method comprising the step of administering a therapeutically or prophylactically effective amount of a compound according to the present invention to a patient. The term "patient" as used herein means a patient requiring the treatment or prevention of the disease for which TGF β inhibition is effective therapeutically or prophylactically.

35 According to the present invention, there is provided use of the compounds according to the present invention, for the manufacture of a medicament used in the treatment or prevention of diseases for which TGF β inhibition is effective therapeutically or prophylactically.

40 [0174] According to the present invention, there is provided a pharmaceutical composition, comprising a compound according to the present invention or a pharmaceutically acceptable salt or solvate thereof. The pharmaceutical composition according to the present invention can be used for the prevention or treatment of diseases for which TGF β inhibition is effective therapeutically or prophylactically.

The disease for which TGF β inhibition is effective therapeutically or prophylactically is preferably a disease involving organ or tissue fibrosis.

45 Further, diseases for which TGF β inhibition is effective therapeutically or prophylactically include chronic renal disease, acute renal disease, hepatic fibrosis, cirrhosis, pulmonary fibrosis, scleroderma, wound healing, arthritis, congestive cardiac disease, ulcer, ocular disorder, corneal problem, diabetic nephropathy, peritoneal sclerosis, arteriosclerosis, peritoneal adhesions, and subdermal adhesion.

50 In another preferred embodiment of the present invention, the disease for which TGF β inhibition is effective therapeutically or prophylactically is a malignant tumor.

[0175] In another preferred embodiment of the present invention, the compounds or pharmaceutical compositions according to the present invention can be used for ex vivo expansion of cells. The cells are preferably hematopoietic stem cells.

55 Accordingly, in a further preferred embodiment of the present invention, there is provided a method for ex vivo expansion of cells, comprising the step of adding a compound according to the present invention or a pharmaceutically acceptable salt or solvate thereof, in an amount effective for promoting cell growth, to intended cells in vitro to amplify the cells.

In another embodiment of the present invention, there is provided a promoter for ex vivo expansion of cells comprising

a compound according to the present invention or a pharmaceutically acceptable salt or solvate thereof.

In still another embodiment of the present invention, there is provided a TGF β inhibitor comprising a compound according to the present invention or a pharmaceutically acceptable salt or solvate thereof.

[0176] The compounds according to the present invention can be administered to human and non-human animals orally or parenterally by administration routes, for example, intravenous administration, intramuscular administration, subcutaneous administration, rectal administration, or percutaneous administration.

Therefore, the pharmaceutical composition comprising a compound according to the present invention may be formulated into suitable dosage forms according to the administration routes. Specifically, oral preparations include tablets, capsules, powders, granules, and syrups, and parenteral preparations include injections, suppositories, tapes, and ointments.

These various preparations may be prepared by conventional methods, for example, with pharmaceutically acceptable carriers, that is, commonly used excipients, disintegrants, binders, lubricants, colorants, and diluents.

Excipients include, for example, lactose, glucose, corn starch, sorbit, and crystalline cellulose. Disintegrants include, for example, starch, sodium alginate, gelatin powder, calcium carbonate, calcium citrate, and dextrin. Binders include, for example, dimethylcellulose, polyvinyl alcohol, polyvinyl ether, methylcellulose, ethylcellulose, gum arabic, gelatin, hydroxypropylcellulose, and polyvinyl pyrrolidone. Lubricants include, for example, talc, magnesium stearate, polyethylene glycol, and hydrogenated vegetable oils.

In preparing the above injections, if necessary, for example, buffering agents, pH adjustors, stabilizers, tonicity adjusting agents, and preservatives may be added.

[0177] The content of a compound according to the present invention in the pharmaceutical composition according to the present invention may vary according to the dosage form. The content, however, is generally 0.5 to 50% by weight, preferably 1 to 20% by weight, based on the whole composition.

The dose may be appropriately determined in consideration of particular conditions, for example, the age, weight, sex, type of disease, and severity of condition of patients. The preparation may be administered, for example, in an amount of 0.1 to 100 mg/kg, preferably 0.1 to 30 mg/kg. This dose may be administered at a time daily or divided doses of several times daily.

Compounds according to the present invention may be administered in combination with other medicaments, for example, carcinostatic agents. The administration can be carried out simultaneously or sequentially. The type, administration interval and the like of the carcinostatic agent can be determined by taking into consideration the type of cancer and the conditions of the patient.

[0178] When the compounds according to the present invention are used in the ex vivo expansion of cells, a suitable medium may be selected or prepared depending upon the type of cells and the like. The amount of the compounds according to the present invention added to the medium may be properly determined depending, for example, upon the type and applications of the cells. The amount is preferably 0.01 to 50 μ M, more preferably 0.1 to 20 μ M.

In another embodiment of the present invention, there is provided a method for inhibiting the action of TGF β on cells, comprising the step of applying an effective amount of a compound according to the present invention to cells present in vitro or in vivo.

[EXAMPLES]

[0179] The present invention is further illustrated by the following Examples. However, it should be noted that embodiments described in the Examples are not intended as a limitation of the invention.

[0180] The compounds according to the present invention were produced as follows.

The relationship between the produced compounds and schemes applied to the production of the compounds are shown in the following table.

[0181]

Scheme	Compound
1	: Partial structure of compounds 1 to 51 Synthesis of partial structures of compounds 103 to 108, 110, 111, 117, 119 to 121, 126, 130, 131, 133, 136 to 146, 154 to 159 and 162 to 177
2	: Partial structure of compounds 52 to 100 Synthesis of partial structures of compounds 101, 102, 113, 114, 116, 118, 123 to 125, 127, 128, 132, 134, 135, 147 to 153, 160 and 161
3	: Compounds 1, 3, 13, 15, 37, 43 to 46, 49, 50, 52 to 54, 81 to 91, 93 to 98, 103, 111, 115, 117, 134, 135, 156, 157 and 188
4	: Compounds 2, 4, 14, 16, 55 to 63, 101, 102, 104, 105, 110, 114, 119, 130 to 133, 150, 158 to 162 and 170
5	: Compounds 28, 29, 71 and 72
6	: Compounds 23 to 27, 38, 39, 41, 48, 51, 68 to 70 and 100
7	: Compounds 32 to 35, 75 to 78 and 180
8	: Compounds 30, 73, 121 and 128

(continued)

Scheme	Compound
9	: Compounds 31 and 74
10	: Compounds 22, 65, 66, 99, 146, 148, 149, 152 and 153
11	: Compounds 5 to 12
12	: Compounds 17 to 21, 106 to 108, 155, 163 to 169 and 171 to 177
13	: Compound 92
14	: Compounds 113, 116, 126, 127, 145, 147, 151, 179, 185, 193, 194 and 217
15	: Compounds 118, 120, 123 to 125, 136 to 144, 178, 181, 183, 184, 186, 190 to 192, 200 to 202, 205, 210, 213 to 216, 222 and 225
16	: Compound 154
17	: Synthesis of partial structure of Compound 115
18	: Compounds 182, 187, 203, 204, 206 to 208 and 224
19	: Compounds 189, 209, 211, 212, 218 to 221 and 223

Example 1: 5,6-Dimethyl-3-(quinolin-4-yloxy)-[2,2']bipyridine (compound 1)

[0182] 2,3-Dimethylfuran (5.0 g) was dissolved in diethyl ether (75 ml) under an argon atmosphere. A 1.6 M n-butyllithium/hexane solution (35.7 ml) was added dropwise to the solution at 0°C, and the mixture was stirred under reflux for 2.5 hr. The mixture was then cooled to -78°C, 2-cyanopyridine (6.0 g) dissolved in diethyl ether (20 ml) was added dropwise thereto, and the mixture was stirred at room temperature for 3 hr. The reaction mixture was poured into ice to stop the reaction and was adjusted to pH 5 by the addition of 2 M hydrochloric acid, followed by extraction with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give (4,5-dimethylfuran-2-yl)-(2-pyridyl)-methanone (1.8 g, yield 17%). (4,5-Dimethylfuran-2-yl)-(2-pyridyl)-methanone (1.6 g), methanol (15 ml), and a 28% aqueous ammonia solution (15 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-ethyl acetate system to give 5,6-dimethyl-[2,2']bipyridinyl-3-ol (1.2 g, yield 75%).

[0183] Dimethyl sulfoxide (1.5 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (30 mg), 4-chloroquinoline (74 mg), and cesium carbonate (147 mg), and the mixture was stirred at 130°C for 7 hr. The reaction mixture was cooled to room temperature, and water was added to the cooled mixture. The mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate system to give the title compound (21 mg, yield 43%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.67 (s, 3H), 6.44 (d, J = 5.2 Hz, 1H), 7.10 (ddd, J = 7.6, 4.9, 1.0 Hz, 1H), 7.37 (s, 1H), 7.53 - 7.60 (m, 2H), 7.73 (ddd, J = 8.3, 6.8, 1.5 Hz, 1H), 7.82 (d, J = 8.0 Hz, 1H), 8.05 (d, J = 8.6 Hz, 1H), 8.35 (dd, J = 8.3, 1.4 Hz, 1H), 8.48 - 8.53 (m, 1H), 7.57 (d, J = 5.2 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 328 (M+1)⁺

Example 2: 3-(6-Bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2)

[0184] Diphenyl ether (80 ml) was added to 4-bromoaniline (4.5 g) and 5-(methoxymethylene)-2,2-dimethyl-1,3-dioxan-4,6-dione (5.4 g), and the mixture was stirred at 80°C for one hr. Biphenyl (24.2 g) was added thereto, and the mixture was stirred at 220°C for 3 hr. The reaction mixture was cooled to room temperature, and diethyl ether was added to the cooled mixture. The precipitated crystal was collected by filtration and was washed with diethyl ether. The residue was purified by column chromatography with a hexane-acetone system to give 6-bromoquinolone (1.57 g, yield 27%). Thionyl chloride (5 ml) and a minor amount of dimethylformamide were added to 6-bromoquinolone (1.6 g), and the mixture was stirred under reflux for 3 hr. The reaction mixture was added to a saturated aqueous sodium bicarbonate solution under ice cooling, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give 6-bromo-4-chloroquinoline (1.43 g, yield 85%).

[0185] Dimethylsulfoxide (25 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (500 mg), 6-bromo-4-chloroquinoline (723 mg), cesium carbonate (2.4 g), and 4-dimethylaminopyridine (916 mg), and the mixture was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous

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sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (886 mg, yield 87%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.66 (s, 3H), 6.44 (d, J = 5.1 Hz, 1H), 7.11 (ddd, J = 7.6, 4.6, 1.0 Hz, 1H), 7.36 (s, 1H), 7.61 (ddd, J = 7.6, 7.6, 1.7 Hz, 1H), 7.79 (dd, J = 8.8, 2.2 Hz, 1H), 7.84 (d, J = 8.0 Hz, 1H), 7.91 (d, J = 9.0 Hz, 1H), 8.42 - 8.47 (m, 1H), 8.52 (d, J = 2.2 Hz, 1H), 8.55 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 406 (M+1)⁺

Example 3: 5,6-Dimethyl-3-(6-trifluoromethyl-quinolin-4-yloxy)-[2,2']bipyridine (compound 3)

[0186] 4-Chloro-6-trifluoromethylquinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (43 mg), and 4-dimethylaminopyridine (79 mg) were dissolved in dimethylsulfoxide (1 ml). Cesium carbonate (211 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The mixture was cooled to room temperature, an aqueous sodium hydrogencarbonate solution was added to the reaction mixture, and the organic layer was extracted with chloroform. The chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (77 mg, yield 89%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 2.68 (s, 3H), 6.57 (d, J = 5.6 Hz, 1H), 7.09 (ddd, J = 1.0, 4.9, 7.6 Hz, 1H), 7.41 (s, 1H), 7.63 (m, 1H), 7.95 - 7.97 (m, 2H), 8.28 (m, 2H), 8.67 (d, J = 5.4 Hz, 1H), 8.73 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 418 (M+Na)⁺

Example 4: 3-(6-Methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 4)

[0187] 4-Methoxyaniline (1.27 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.82 g) were dissolved in 2-propanol (40 ml), and the solution was stirred at 50°C for 2 hr. The solvent was removed by distillation under the reduced pressure, and the residue was washed with ether to give 5-[(4-methoxy-phenylamino)-methylene]-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.98 g, yield 73%).

5-[(4-Methoxy-phenylamino)-methylene]-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.28 g) and biphenyl (5.2 g) were suspended in diphenyl ether (20 ml), and the suspension was stirred at 220°C for one hr. The reaction mixture as such was purified by column chromatography with a methanol-chloroform system to give 6-methoxy-1H-quinolin-4-one (398 mg, yield 49%).

6-Methoxy-1H-quinolin-4-one (398 mg) was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (1 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. Water was added to the reaction mixture under ice cooling, and the aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution. The organic layer was extracted with ethyl acetate, and the ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 4-chloro-6-methoxyquinoline (375 mg, yield 42%).

[0188] 4-Chloro-6-methoxyquinoline (270 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (279 mg), and 4-dimethylaminopyridine (510 mg) were dissolved in dimethylsulfoxide (4 ml), cesium carbonate (1.36 g) was added to the solution, and the mixture was stirred at 130°C overnight. The mixture was cooled to room temperature, an aqueous sodium hydrogencarbonate solution was added to the reaction mixture, and the organic layer was extracted with chloroform. The chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (411 mg, yield 83%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.66 (s, 3H), 3.95 (s, 3H), 6.45 (dd, J = 0.7, 5.1 Hz, 1H), 7.11 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.37 (s, 1H), 7.39 (m, 1H), 7.57 - 7.61 (m, 2H), 7.82 (dd, J = 1.0, 7.8 Hz, 1H), 7.99 (d, J = 9.3 Hz, 1H), 8.44 (d, J = 5.1 Hz, 1H), 8.50 (d, J = 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 380 (M+Na)⁺

Example 5: 5,6-Dimethyl-3-(6-phenyl-quinolin-4-yloxy)-[2,2']bipyridine (compound 5)

[0189] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and phenylboric acid (27 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, and water was added to the cooled mixture. The mixture was extracted with ethyl acetate, the ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent

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was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.67 (s, 3H), 6.47 (d, J = 5.1 Hz, 1H), 7.09 (ddd, J = 7.3, 4.9, 1.0 Hz, 1H), 7.37 - 7.43 (m, 2H), 7.50 (dd, J = 7.8, 7.8 Hz, 2H), 7.56 (ddd, J = 7.8, 7.8, 2.0 Hz, 1H), 7.76 (d, J = 7.3 Hz, 2H), 7.83 (d, J = 8.0 Hz, 1H), 8.01 (dd, J = 9.0, 2.2 Hz, 1H), 8.11 (d, J = 8.8 Hz, 1H), 8.48 - 8.51 (m, 1H), 8.54 - 8.59 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 404 (M+1)⁺

Example 6: 5,6-Dimethyl-3-(6-pyridin-3-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 6)

[0190] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 3-pyridylboric acid (18 mg) under an argon atmosphere, and the mixture was stirred at 70 °C for 3 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (30 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.49 (d, J = 5.4 Hz, 1H), 7.09 (ddd, J = 7.6, 4.9, 1.0 Hz, 1H), 7.38 - 7.46 (m, 2H), 7.59 (ddd, J = 7.8, 7.8, 2.0 Hz, 1H), 7.85 (ddd, J = 8.0, 1.2, 1.2 Hz, 1H), 7.98 (dd, J = 8.8, 2.2 Hz, 1H), 8.02 - 8.07 (m, 1H), 8.16 (d, J = 8.8 Hz, 1H), 8.43 - 8.47 (m, 1H), 8.57 (d, J = 2.0 Hz, 1H), 8.60 (d, J = 5.1 Hz, 1H), 8.65 (dd, J = 4.9, 1.7 Hz, 1H), 9.00 (d, J = 1.7 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 427 (M+Na)⁺

Example 7: 5,6-Dimethyl-3-(6-pyridin-4-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 7)

[0191] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg) and tetrakis(triphenylphosphine) palladium (9 mg) and 4-pyridylboric acid (18 mg) under an argon atmosphere, and the mixture was stirred at 70 °C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (16 mg, yield 55%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.49 (d, J = 5.4 Hz, 1H), 7.09 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.41 (s, 1H), 7.59 (ddd, J = 7.6, 7.6, 1.7 Hz, 1H), 7.68 (dd, J = 4.6, 1.7 Hz, 2H), 7.86 (d, J = 8.0 Hz, 1H), 8.02 (dd, J = 8.8, 2.2 Hz, 1H), 8.16 (d, J = 8.8 Hz, 1H), 8.40 - 8.45 (m, 1H), 8.61 (d, J = 5.1 Hz, 1H), 8.66 (d, J = 2.2 Hz, 1H), 8.73 (dd, J = 6.4, 1.7 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 405 (M+1)⁺

Example 8: 5,6-Dimethyl-3-(6-p-tolyl-quinolin-4-yloxy)-[2,2']bipyridine (compound 8)

[0192] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 4-methylphenylboric acid (30 mg) under an argon atmosphere and the mixture was stirred at 70 °C for 3 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.43 (s, 3H), 2.67 (s, 3H), 6.46 (d, J = 5.1 Hz, 1H), 7.09 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.30 (d, J = 7.8 Hz, 2H), 7.39 (s, 1H), 7.56 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.66 (d, J = 8.0 Hz, 2H), 7.83 (d, J = 7.8 Hz, 1H), 8.00 (dd, J = 8.8, 2.0 Hz, 1H), 8.10 (d, J = 8.8 Hz, 1H), 8.49 - 8.54 (m, 2H), 8.55 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 418 (M+1)⁺

Example 9: 2-[4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-quinolin-6-yl]-phenylamine (compound 9)

[0193] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 2-aminophenylboric acid (30 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.66 (s, 3H), 3.83 (brs, 2H), 6.47 (d, J = 5.1 Hz, 1H), 6.82 (dd, J = 8.0, 1.0 Hz, 1H), 6.88 (ddd, J = 8.6, 8.6, 1.2 Hz, 1H), 7.08 - 7.13 (m, 1H), 7.18 - 7.26 (m, 2H), 7.37 (s, 1H), 7.57 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.82 (ddd, J = 8.1, 8.1, 1.2 Hz, 1H), 7.87 (dd, J = 8.8, 2.0 Hz, 1H), 8.11 (d, J = 8.8 Hz, 1H), 8.43 (d, J = 2.0 Hz, 1H), 8.49 - 8.52 (m, 1H), 8.59 (d, J = 5.2 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 441 (M+Na)⁺

Example 10: 3-[4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-quinolin-6-yl]-phenylamine (compound 10)

[0194] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 3-aminophenylboric acid monohydrate (34 mg) under an argon atmosphere, and the mixture was stirred at 70°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate, and the ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 3.80 (brs, 2H), 6.45 (d, J = 5.1 Hz, 1H), 6.70 - 6.76 (m, 1H), 7.02 - 7.17 (m, 3H), 7.26 - 7.31 (m, 1H), 7.38 (s, 1H), 7.57 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.83 (d, J = 8.0 Hz, 1H), 7.98 (dd, J = 8.8, 2.0 Hz, 1H), 8.09 (d, J = 8.8 Hz, 1H), 8.47 - 8.54 (m, 2H), 8.56 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 441 (M+Na)⁺

Example 11: 3-[4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-quinolin-6-yl]-phenol (compound 11)

[0195] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg) and 3-hydroxyphenylboric acid (31 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.33 (s, 3H), 2.61 (s, 3H), 6.40 (d, J = 5.1 Hz, 1H), 6.77 - 6.84 (m, 1H), 7.06 (ddd, J = 7.6, 4.9, 1.0 Hz, 1H), 7.18 - 7.34 (m, 4H), 7.55 (ddd, J = 7.8, 7.8, 2.0 Hz, 1H), 7.79 (ddd, J = 8.0, 1.0, 1.0 Hz, 1H), 7.93 (dd, J = 9.0, 2.2 Hz, 1H), 8.09 (d, J = 8.8 Hz, 1H), 8.42 - 8.47 (m, 1H), 8.53 (d, J = 5.4 Hz, 1H), 8.57 (d, J = 2.2 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 420 (M+1)⁺

Example 12: 4-[4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-quinolin-6-yl]-phenol (compound 12)

[0196] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 4-hydroxyphenylboric acid (31 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate.

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The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.38 (s, 3H), 2.65 (s, 3H), 6.46 (d, J = 5.1 Hz, 1H), 6.95 (d, J = 8.5 Hz, 2H), 7.11 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.39 (s, 1H), 7.54 - 7.64 (m, 3H), 7.85 (d, J = 8.1 Hz, 1H), 7.95 (dd, J = 8.8, 2.0 Hz, 1H), 8.09 (d, J = 8.8 Hz, 1H), 8.48 - 8.51 (m, 2H), 8.54 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 420 (M+1)⁺

Example 13: 3-(7-Chloro-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 13)

[0197] Dimethylsulfoxide (2.5 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (50 mg), 4,7-dichloroquinoline (99 mg), and cesium carbonate (244 mg), and the mixture was stirred at 130°C for 3 hr. 4,7-Dichloroquinoline (99 mg) was further added thereto, and the mixture was stirred at 130°C for 3 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (80 mg, yield 88%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.66 (s, 3H), 6.41 (d, J = 5.1 Hz, 1H), 7.09 (ddd, J = 7.3, 4.6, 1.0 Hz, 1H), 7.38 (s, 1H), 7.51 (dd, J = 9.0, 2.2 Hz, 1H), 7.58 (ddd, J = 8.0, 8.0, 2.0 Hz, 1H), 7.82 (ddd, J = 8.1, 1.0, 1.0 Hz, 1H), 8.03 (d, J = 2.0 Hz, 1H), 8.29 (d, J = 8.8 Hz, 1H), 8.40 - 8.45 (m, 1H), 8.55 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 362 (M+1)⁺

Example 14: 3-(7-Bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14)

[0198] 2-Propanol (90 ml) was added to 3-bromoaniline (5.0 g), and 5-(methoxymethylene)-2,2-dimethyl-1,3-dioxan-4,6-dione (6.0 g) was added to the mixture with stirring at 70°C, and the mixture was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with diethyl ether. The crude crystal thus obtained as such was used in the next reaction without purification.

Biphenyl (26.2 g) and diphenyl ether (75 ml) were added to the crude crystal, and the mixture was stirred at 230°C for one hr. The reaction mixture was cooled to room temperature, and ether was added to the cooled mixture. The precipitated crystal was collected by filtration and was washed with diethyl ether, and the crude crystal thus obtained as such was used in the next reaction without purification.

Thionyl chloride (15 ml) and a minor amount of dimethylformamide were added to the crude crystal, and the mixture was stirred under reflux for 3 hr. The reaction mixture was added to a saturated aqueous sodium bicarbonate solution under ice cooling, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give 7-bromo-4-chloroquinoline (2.40 g, yield 42%).

[0199] Dimethylsulfoxide (25 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (500 mg), 7-bromo-4-chloroquinoline (723 mg), cesium carbonate (2.4 g), and 4-dimethylaminopyridine (916 mg), and the mixture was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (705 mg, yield 70%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.66 (s, 3H), 6.43 (d, J = 5.1 Hz, 1H), 7.09 (dd, J = 7.6, 4.6 Hz, 1H), 7.38 (s, 1H), 7.58 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.64 (dd, J = 9.0, 1.7 Hz, 1H), 7.82 (d, J = 8.1 Hz, 1H), 8.20 - 8.25 (m, 2H), 8.41 - 8.45 (m, 1H), 8.55 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 406 (M+1)⁺

Example 15: 5,6-Dimethyl-3-(7-trifluoromethyl-quinolin-4-yloxy)-[2,2']bipyridine (compound 15)

[0200] Dimethylsulfoxide (2.5 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (50 mg), 4-chloro-7-trifluoromethyl-quinoline (116 mg), and cesium carbonate (244 mg), and the mixture was stirred at 130°C for 3 hr. 4-Chloro-7-trifluoromethyl-quinoline (116 mg) was further added, and the mixture was stirred at 130°C for 3 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (98 mg, yield 99%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.52 (d, J = 5.4 Hz, 1H), 7.09 (ddd, J = 7.4, 4.7, 1.1 Hz, 1H),

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7.40 (s, 1H), 7.60 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.73 (dd, J = 8.8, 1.7 Hz, 1H), 7.86 (ddd, J = 7.8, 1.0, 1.0 Hz, 1H), 8.35 (s, 1H), 8.37 (s, 1H), 8.41 (m, 1H), 8.49 (d, J = 8.8 Hz, 1H), 8.65 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 396 (M+1)⁺

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Example 16: 3-(7-Methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 16)

[0201] 3-Methoxyaniline (1.23 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.90 g) were dissolved in 2-propanol (40 ml), and the mixture was stirred at 70°C for one hr. The solvent was removed by distillation under the reduced pressure, and the residue was washed with ether to give 5-[(3-methoxy-phenylamino)-methylene]-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.22 g, yield 44%).

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5-[(3-Methoxy-phenylamino)-methylene]-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.22 g) and biphenyl (5.1 g) were suspended in diphenyl ether (15 ml), and the mixture was stirred at 220°C for 1.5 hr. The reaction mixture as such was purified by column chromatography with a methanol-chloroform system to give 7-methoxy-1H-quinolin-4-one (394 mg, yield 51%).

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7-Methoxy-1H-quinolin-4-one (394 mg) was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (1 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 4-chloro-7-methoxyquinoline (312 mg, yield 72%).

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[0202] 4-Chloro-7-methoxyquinoline (170 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (176 mg), and 4-dimethylaminopyridine (322 mg) were dissolved in dimethylsulfoxide (2 ml). Cesium carbonate (860 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The mixture was cooled to room temperature. An aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (273 mg, yield 87%). ¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.66 (s, 3H), 3.96 (d, J = 1.2 Hz, 3H), 6.34 (dd, J = 2.2, 5.4 Hz, 1H), 7.10 (m, 1H), 7.21 (m, 1H), 7.36 (s, 1H), 7.40 (m, 1H), 7.57 (m, 1H), 7.81 (dd, J = 1.2, 8.1 Hz, 1H), 8.23 (dd, J = 1.5, 9.3 Hz, 1H), 8.48 - 8.49 (m, 2H)
Mass spectrometric value (ESI-MS, m/z): 380 (M+Na)⁺

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Example 17: 5,6-Dimethyl-3-(7-phenyl-quinolin-4-yloxy)-[2,2']bipyridine (compound 17)

[0203] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and phenylboric acid (27 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (30 mg, yield 100%).

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¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 6.44 (d, J = 5.2 Hz, 1H), 7.10 (ddd, J = 7.3, 4.6, 1.0 Hz, 1H), 7.39 - 7.45 (m, 2H), 7.51 (dd, J = 7.8, 7.8 Hz, 2H), 7.58 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.75 - 7.79 (m, 2H), 7.82 - 7.87 (m, 2H), 8.27 (d, J = 1.7 Hz, 1H), 8.41 (d, J = 8.6 Hz, 1H), 8.50 - 8.53 (m, 1H), 8.59 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 426 (M+Na)⁺

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Example 18: 5,6-Dimethyl-3-(7-pyridin-3-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 18)

[0204] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 3-pyridylboric acid (18 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography

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with a chloroform-methanol system to give the title compound (30 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.68 (s, 3H), 6.47 (d, J = 5.1 Hz, 1H), 7.10 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.40 (s, 1H), 7.44 (ddd, J = 7.8, 4.9, 0.7 Hz, 1H), 7.59 (ddd, J = 8.1, 8.1, 2.0 Hz, 1H), 7.81 (dd, J = 8.8, 2.0 Hz, 1H), 7.86 (d, J = 8.0 Hz, 1H), 8.05 (dd, J = 8.0, 2.4 Hz, 1H), 8.27 (d, J = 1.5 Hz, 1H), 8.45 - 8.50 (m, 2H), 8.61 (d, J = 5.4 Hz, 1H), 8.67 (dd, J = 4.9, 1.7 Hz, 1H), 9.03 (d, J = 1.5 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 427 (M+Na)⁺

Example 19: 5,6-Dimethyl-3-(7-pyridin-4-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 19)

[0205] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 4-pyridylboric acid (18 mg) under an argon atmosphere, and the mixture was stirred at 70 °C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (13 mg, yield 43%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.68 (s, 3H), 6.48 (d, J = 5.1 Hz, 1H), 7.10 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.41 (s, 1H), 7.60 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.68 (dd, J = 4.6, 1.7 Hz, 2H), 7.82 - 7.88 (m, 2H), 8.34 (d, J = 2.0 Hz, 1H), 8.45 - 8.50 (m, 2H), 8.62 (d, J = 5.2 Hz, 1H), 8.74 (dd, J = 4.6, 1.7 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 427 (M+Na)⁺

Example 20: 5,6-Dimethyl-3-(7-p-tolyl-quinolin-4-yloxy)-[2,2']bipyridine (compound 20)

[0206] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 4-methylphenylboric acid (30 mg) under an argon atmosphere, and the mixture was stirred at 70 °C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.43 (s, 3H), 2.67 (s, 3H), 6.42 (d, J = 5.1 Hz, 1H), 7.10 (ddd, J = 7.6, 4.9, 1.0 Hz, 1H), 7.32 (d, J = 7.8 Hz, 2H), 7.38 (s, 1H), 7.58 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.67 (d, J = 8.0 Hz, 2H), 7.80 - 7.86 (m, 2H), 8.25 (d, J = 1.5 Hz, 1H), 8.39 (d, J = 8.8 Hz, 1H), 8.50 - 8.54 (m, 1H), 8.58 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 440 (M+Na)⁺

Example 21: 3-[4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-quinolin-7-yl]-phenylamine (compound 21)

[0207] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 3-aminophenylboric acid monohydrate (34 mg) under an argon atmosphere, and the mixture was stirred at 70 °C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.67 (s, 3H), 3.81 (brs, 2H), 6.43 (d, J = 5.1 Hz, 1H), 6.74 (ddd, J = 8.0, 2.2, 1.0 Hz, 1H), 7.05 - 7.18 (m, 3H), 7.29 (dd, J = 8.1, 8.1 Hz, 1H), 7.38 (s, 1H), 7.58 (ddd, J = 7.8, 7.8, 2.0 Hz, 1H), 7.80 (dd, J = 8.8, 2.0 Hz, 1H), 7.84 (d, J = 7.8 Hz, 1H), 8.23 (d, J = 1.7 Hz, 1H), 8.37 (d, J = 8.6 Hz, 1H), 8.50 - 8.54 (m, 1H), 8.58 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 441 (M+Na)⁺

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Example 22: 4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-7-methoxy-quinoline-6-carboxylic acid amide (compound 22)

[0208] Methyl 4-amino-2-methoxy-benzoate (1.07 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.0 g) were dissolved in 2-propanol (20 ml), and the mixture was stirred at 70°C for one hr. The solvent was removed by distillation under the reduced pressure, and the residue was washed with ether to give methyl 4-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidenemethyl)-amino]-2-methoxy-benzoate (1.71 g, yield 95%).

Methyl 4-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidenemethyl)-amino]-2-methoxy-benzoate (1.70 g) and biphenyl (4.76 g) were suspended in diphenyl ether (15 ml), and the suspension was stirred at 240°C for one hr. The suspension was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with ether. The crystal thus obtained as such was used in the next reaction without further purification.

N,N-Dimethylformamide (2 drops) was added to the crystal thus obtained. Further, phosphorus oxychloride (2.5 ml) was added thereto, and the mixture was stirred at 100°C for 2 hr. The solvent was removed by distillation under the reduced pressure, and water was added to the residue under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give methyl 4-chloro-7-methoxy-quinoline-6-carboxylate (707 mg, yield 55%) (2 steps).

[0209] Methyl 4-chloro-7-methoxy-quinoline-6-carboxylate (120 mg) was dissolved in methanol (6 ml), 28% aqueous ammonia (6 ml) was added thereto, and the mixture was stirred at 40°C overnight. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4-chloro-7-methoxy-quinoline-6-carboxylic acid amide (91 mg, yield 80%).

4-Chloro-7-methoxy-quinoline-6-carboxylic acid amide (91 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (115 mg), and 4-dimethylaminopyridine (141 mg) were dissolved in dimethylsulfoxide (3 ml), cesium carbonate (375 mg) was added to the solution, and the mixture was stirred overnight at 130°C. The mixture was cooled to room temperature, and water was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (33 mg, yield 22%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 4.13 (s, 3H), 5.92 (m, 1H), 6.39 (d, J = 5.4 Hz, 1H), 7.08 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.36 (s, 1H), 7.56 - 7.63 (m, 2H), 7.76 (m, 1H), 7.90 (m, 1H), 8.40 (m, 1H), 8.54 (d, J = 5.6 Hz, 1H), 9.27 (d, J = 1.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 423 (M+Na)⁺

Example 23: 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinazoline (compound 23)

[0210] Formamide (12 ml) was added to methyl 2-aminobenzoate (2.0 g), and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with chloroform/methanol. The solvent was removed from the organic layer by distillation under the reduced pressure, and the residue was used in the next reaction without purification.

Ethyl-diisopropylamine (1.6 g) and phosphorus oxychloride (3.8 g) were added to the residue, and the mixture was stirred under reflux for 2 hr. The reaction mixture was cooled to room temperature, and the cooled mixture was poured into an ice cooled saturated aqueous sodium bicarbonate solution. The mixture was stirred for 10 min and was extracted with chloroform. The organic layer was washed with a saturated aqueous sodium bicarbonate solution and water in that order and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give 4-chloroquinazoline (1.03 g, yield 60%).

Dimethylsulfoxide (2.5 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (50 mg), 4-chloroquinazoline (82 mg), and cesium carbonate (244 mg), and the mixture was stirred at 120°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography using ethyl acetate as developing phase to give the title compound (27 mg, yield 33%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.63 (s, 3H), 7.04 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.49 (s, 1H), 7.58 - 7.68 (s, 2H), 7.86 - 8.00 (m, 3H), 8.18 (d, J = 4.6 Hz, 1H), 8.35 (d, J = 8.1 Hz, 1H), 8.63 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 351 (M+Na)⁺

Example 24: 6-Chloro-4-(5,6-dimethyl-[2,2']bipyridin-3-yloxy)-quinazoline (compound 24)

[0211] Formamide (4 ml) was added to methyl 2-amino-5-chloro-benzoate (400 mg), and the mixture was stirred with a microwave reactor at 220°C for 20 min. The above reaction was carried out by additional two batches using the same amounts of starting materials. Thereafter, the reaction mixtures were cooled to room temperature and were combined together, and the precipitated crystal was collected by filtration and was washed with ether. The crystal (1.19 g) thus obtained as such was used in the next reaction without further purification.

A part (300 mg) of the crystal obtained above was suspended in diisopropylethylamine (1.45 ml), phosphorus oxychloride (0.77 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. The solvent was removed by distillation under the reduced pressure. Water was added to the reaction mixture under ice cooling, the aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4,6-dichloro-quinazoline (151 mg, yield 46%).

[0212] 4,6-Dichloro-quinazoline (66 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (66 mg), and 4-dimethylaminopyridine (121 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for one hr. The suspension was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was then added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (99 mg, yield 83%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 2.64 (s, 3H), 7.08 (m, 1H), 7.48 (s, 1H), 7.67 (m, 1H), 7.83 (ddd, J = 0.7, 2.4, 9.0 Hz, 1H), 7.92 (d, J = 9.0 Hz, 1H), 8.02 (dd, J = 1.0, 8.1 Hz, 1H), 8.17 (s, 1H), 8.36 (m, 1H), 8.61 (s, 1H)
Mass spectrometric value (ESI-MS, m/z): 385 (M+Na)⁺

Example 25: 6-Bromo-4-(5,6-dimethyl-[2,2']bipyridin-3-yloxy)-quinazoline (compound 25)

[0213] Formamide (4 ml) was added to methyl 2-amino-5-bromo-benzoate (400 mg), and the mixture was stirred with a microwave reactor at 220°C for 20 min. The above reaction was carried out using the same amount of starting materials by additional two batches. The reaction mixtures were cooled to room temperature and were combined together. The precipitated crystal was collected by filtration and was washed with ether. The crystal (968 mg) thus obtained as such was used in the next reaction without further purification.

A part (300 mg) of the crystal obtained above was suspended in diisopropylethylamine (1.16 ml), phosphorus oxychloride (0.62 ml) was added to the suspension, and the mixture was stirred at 100°C for 2 hr. The solvent was removed by distillation under the reduced pressure, and water was added to the residue under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 6-bromo-4-chloro-quinazoline (58 mg, yield 18%).

[0214] 6-Bromo-4-chloro-quinazoline (69 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (57 mg), and 4-dimethylaminopyridine (104 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for one hr. The reaction mixture was then cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (59 mg, yield 52%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 2.65 (s, 3H), 7.08 (m, 1H), 7.48 (s, 1H), 7.68 (m, 1H), 7.85 (d, J = 8.8 Hz, 1H), 7.97 (ddd, J = 0.7, 2.2, 8.8 Hz, 1H), 8.02 (d, J = 7.8 Hz, 1H), 8.18 (m, 1H), 8.54 (d, J = 2.0 Hz, 1H), 8.62 (s, 1H)
Mass spectrometric value (ESI-MS, m/z): 429 (M+Na)⁺

Example 26: 4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-6-methoxy-quinazoline (compound 26)

[0215] 5-Methoxy-2-nitro-benzoic acid (3.2 g) was dissolved in N,N-dimethylformamide (60 ml). Potassium carbonate (5.61 g) and methyl iodide (5.05 ml) were added to the solution, and the mixture was stirred at room temperature overnight. Water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-hexane system to give methyl 5-methoxy-2-nitro-benzoate (3.38 g, yield 99%).

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Methyl 5-methoxy-2-nitro-benzoate (3.38 g) was dissolved in N,N-dimethylformamide (34 ml). Triethylamine (7 ml) and 20% palladium hydroxide (340 mg) were added to the solution, and the mixture was stirred under a hydrogen gas atmosphere at room temperature overnight. The reaction mixture was filtered and was washed with chloroform. The solvent was removed by distillation under the reduced pressure, water was added to the residue, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine, was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-hexane system to give methyl 2-amino-5-methoxy-benzoate (2.87 g, yield 99%).

[0216] Formamide (4 ml) was added to methyl 2-amino-5-methoxy-benzoate (400 mg), and the mixture was stirred with a microwave reactor at 220°C for 20 min. Further, a reaction was carried out in the same manner as described above, except that methyl 2-amino-5-methoxy-benzoate (100 mg x 2, 350 mg x 5) was used. The reaction mixtures were cooled to room temperature and were combined together. Water was added thereto, the organic layer was extracted with methanol/chloroform, and the extract was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue (5.76 g) as such was used in the next reaction without further purification. A part (1 g) of the residue obtained above was suspended in diisopropylethylamine (4.94 ml), phosphorus oxychloride (2.65 ml) was added thereto, and the mixture was stirred at 100°C for one hr. The solvent was removed by distillation under the reduced pressure, and water was added to the residue under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4-chloro-6-methoxy-quinazoline (304 mg, yield 69%) (2 steps).

[0217] 4-Chloro-6-methoxy-quinazoline (40 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (41 mg), and 4-dimethylaminopyridine (75 mg) were dissolved in dimethylsulfoxide (1 ml), cesium carbonate (201 mg) was added thereto, and the mixture was stirred at 130°C overnight. The mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was then added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (27 mg, yield 35%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 2.64 (s, 3H), 3.96 (s, 3H), 7.07 (m, 1H), 7.50 (s, 1H), 7.52 (dd, J = 2.9, 9.3 Hz, 1H), 7.60 (d, J = 2.7 Hz, 1H), 7.64 (ddd, J = 1.7, 7.8, 7.8 Hz, 1H), 7.88 (d, J = 9.0 Hz, 1H), 7.93 (d, J = 7.8 Hz, 1H), 8.24 (d, J = 4.1 Hz, 1H), 8.51 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 381 (M+Na)⁺

Example 27: 4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-6,7-dimethoxy-quinazoline (compound 27)

[0218] Dimethylsulfoxide (2.5 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (50 mg), 4-chloro-6,7-dimethoxy-quinazoline (169 mg), and cesium carbonate (244 mg), and the mixture was stirred at 120°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate system to give the title compound (79 mg, yield 81%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.63 (s, 3H), 4.03 (s, 3H), 4.05 (s, 3H), 7.06 (ddd, 7.6, 4.9, 1.2 Hz, 1H), 7.28 (s, 1H), 7.50 (s, 1H), 7.55 (s, 1H), 7.62 (ddd, J = 7.6, 4.9, 1.7 Hz, 1H), 7.89 (d, J = 7.8 Hz, 1H), 8.26 (d, J = 4.1 Hz, 1H), 8.48 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 411 (M+Na)⁺

Example 28: 5,6-Dimethyl-3-(thieno[3,2-b]pyridin-7-yloxy)-[2,2']bipyridine (compound 28)

[0219] 1-(3-Amino-thiophen-2-yl)-ethanone (423 mg) was dissolved in tetrahydrofuran (30 ml). Ethyl formate (3 ml) and sodium methoxide (640 mg) were added to the solution, and the mixture was stirred at room temperature for 3 hr. Water was added to the reaction mixture, and the organic layer was extracted with methanol/chloroform and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4H-thieno[3,2-b]pyridin-7-one (95 mg, yield 21%).

4H-Thieno[3,2-b]pyridin-7-one (94 mg) was suspended in diisopropylethylamine (2 ml), phosphorus oxychloride (0.5 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was

dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-chloroform system to give 7-chloro-thieno[3,2-b]pyridine (84 mg, yield 79%).

[0220] 7-Chloro-thieno[3,2-b]pyridine (43 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (51 mg), and 4-dimethylaminopyridine (93 mg) were dissolved in dimethylsulfoxide (1.5 ml). Cesium carbonate (248 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The mixture was cooled to room temperature, and water was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (67 mg, yield 80%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.66 (s, 3H), 6.49 (d, J = 5.4 Hz, 1H), 7.12 (dd, J = 4.9, 6.8 Hz, 1H), 7.39 (s, 1H), 7.61 - 7.65 (m, 2H), 7.79 (d, J = 5.6 Hz, 1H), 7.90 (m, 1H), 8.40 (dd, J = 0.7, 5.6 Hz, 1H), 8.44 (m, 1H)
Mass spectrometric value (ESI-MS, m/z): 356 (M+Na)⁺

Example 29: 5,6-Dimethyl-3-(2-phenyl-thieno[3,2-b]pyridin-7-yloxy)-[2,2']bipyridine (compound 29)

[0221] 1-(3-Amino-5-phenyl-thiophen-2-yl)-ethanone (640 mg) was dissolved in tetrahydrofuran (30 ml). Ethyl formate (3 ml) and sodium methoxide (640 mg) were added to the solution, and the mixture was stirred at room temperature for 3 hr. Water was added to the reaction mixture, and the organic layer was extracted with methanol/chloroform and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was washed with chloroform to give 2-phenyl-4H-thieno[3,2-b]pyridin-7-one (462 mg, yield 69%).

2-Phenyl-4H-thieno[3,2-b]pyridin-7-one (493 mg) was suspended in diisopropylethylamine (4 ml). Phosphorus oxychloride (1.5 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 7-chloro-2-phenyl-thieno[3,2-b]pyridine (390 mg, yield 73%).

[0222] 7-Chloro-2-phenyl-thieno[3,2-b]pyridine (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (41 mg), and 4-dimethylaminopyridine (75 mg) were dissolved in dimethylsulfoxide (1.5 ml). Cesium carbonate (199 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The mixture was cooled to room temperature, and water was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (71 mg, yield 87%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.46 (d, J = 5.9 Hz, 1H), 7.13 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.41 (s, 1H), 7.42 - 7.52 (m, 3H), 7.65 (ddd, J = 1.7, 7.8, 7.8 Hz, 1H), 7.76 (m, 2H), 7.83 (s, 1H), 7.93 (d, J = 7.8 Hz, 1H), 8.36 (d, J = 5.9 Hz, 1H), 8.46 (d, J = 4.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 432 (M+Na)⁺

Example 30: 4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-[1,5]naphthyridine (compound 30)

[0223] [1,5]Naphthyridin-4-ol (200 mg) was suspended in thionyl chloride (3.0 ml), N,N-dimethylformamide (3 drops) was added to the suspension, and the mixture was stirred at 100°C for 4 hr. The solvent was removed by distillation under the reduced pressure. Water was added to the residue, and the solution was rendered weakly basic by the addition of a saturated aqueous sodium hydrogencarbonate solution. Chloroform was added thereto, and the mixture was extracted, and the chloroform layer was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 4-chloro-[1,5]naphthyridine (348 mg, yield 62%).

4-Chloro-[1,5]naphthyridine (41 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (20 mg), and 4-dimethylaminopyridine (37 mg), and cesium carbonate (98 mg) were suspended in dimethylsulfoxide (1.5 ml), and the suspension was stirred at 140°C for 24 hr. The reaction mixture was cooled to room temperature, water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (7 mg, yield 21%).
¹H-NMR (CDCl₃, 400 MHz): δ 2.38 (s, 3H), 2.66 (s, 3H), 6.65 (d, J = 5.2 Hz, 1H), 7.04 (m, 1H), 7.41 (s, 1H), 7.51 (m, 1H), 7.68 (dd, J = 8.4, 4.0 Hz, 1H), 7.96 (d, J = 8.0 Hz, 1H), 8.36 (dd, J = 8.4, 2.0 Hz, 1H), 8.41 (d, J = 4.0 Hz, 1H), 8.60 (d, J = 5.2 Hz, 1H), 9.01 (dd, J = 4.0, 1.6 Hz, 1H)

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Mass spectrometric value (ESI-MS, m/z): 351 (M+Na)⁺

Example 31: 4-(5,6-Dimethyl-[2,2']bipyridin-3-yloxy)-[1,6]naphthyridine (compound 31)

5 **[0224]** 4-Amino-2,6-dichloropyridine (1.76 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.05 g) were dissolved in 2-propanol (50 ml), and the solution was stirred at 70 °C for 4 hr. The solvent was removed by distillation under the reduced pressure, and the residue was washed with 2-propanol to give 5-[(2,6-dichloro-pyridin-4-ylamino)-methylene]-2,2-dimethyl-[1,3]dioxan-4,6-dione (3.21 g, yield 94%).

10 5-[(2,6-Dichloro-pyridin-4-ylamino)-methylene]-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.03 g) and biphenyl (5.1 g) were suspended in diphenyl ether (17 ml), and the suspension was stirred at 220 °C for 2 hr. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with chloroform. The crystal thus obtained as such was used in the next reaction without further purification.

15 The crystal (0.58 g) thus obtained was dissolved in N,N-dimethylformamide (12 ml). Triethylamine (1.5 ml) and 20% palladium hydroxide (0.48 g) were added to the solution, and the mixture was stirred under a hydrogen gas atmosphere at room temperature overnight. The reaction mixture was filtered and was washed with chloroform. The solvent was removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without further purification.

20 **[0225]** The residue was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (0.7 ml) was added to the suspension, and the mixture was stirred at 100 °C for 4 hr. Water was added to the reaction mixture under ice cooling, the aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with chloroform and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 4-chloro-[1,6]naphthyridine (63 mg, yield 12%) (3 steps).

25 4-Chloro-[1,6]naphthyridine (39 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (47 mg), and 4-dimethylaminopyridine (86 mg) were dissolved in dimethylsulfoxide (1 ml). Cesium carbonate (229 mg) was added to the solution, and the mixture was stirred at 130 °C overnight. The reaction mixture was cooled to room temperature, and water was then added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (70 mg, yield 92%).

30 ¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 2.67 (s, 3H), 6.52 (d, J = 5.4 Hz, 1H), 7.09 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.43 (s, 1H), 7.62 (ddd, J = 2.0, 7.8, 7.8 Hz, 1H), 7.87 (d, J = 5.9 Hz, 1H), 7.92 (d, J = 8.1 Hz, 1H), 8.35 (m, 1H), 8.71 (d, J = 5.4 Hz, 1H), 8.79 (d, J = 5.9 Hz, 1H), 9.78 (s, 1H)

35 Mass spectrometric value (ESI-MS, m/z): 351 (M+Na)⁺

Example 32: 5,6-Dimethyl-3-(thieno[2,3-d]pyrimidin-4-yloxy)-[2,2']bipyridine (compound 32)

40 **[0226]** Formamide (4 ml) was added to methyl 2-amino-thiophene-3-carboxylate (400 mg), and the mixture was stirred with a microwave reactor at 220 °C for 20 min. The above reaction was carried out using the same amount of starting materials by additional two batches. The reaction mixtures were cooled to room temperature and were combined together. Water was added thereto, and the organic layer was extracted with methanol/chloroform and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue (1.28 g) as such was used in the next reaction without further purification.

45 A part (300 mg) of the residue was suspended in diisopropylethylamine (1.72 ml). Phosphorus oxychloride (0.92 ml) was added to the suspension, and the mixture was stirred at 100 °C for one hr. The solvent was removed by distillation under the reduced pressure. Water was then added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4-chloro-thieno[2,3-d]pyrimidine (151 mg, yield 49%) (2 steps).

50 **[0227]** 4-Chloro-thieno[2,3-d]pyrimidine (40 mg), 5,6-dimethyl-[2,2']bipyridin-3-ol (47 mg), and 4-dimethylaminopyridine (86 mg) were dissolved in dimethylsulfoxide (1 ml). Cesium carbonate (229 mg) was added to the solution, and the mixture was stirred at 130 °C overnight. The reaction mixture was cooled to room temperature, and water was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (62 mg, yield 81%).

55 ¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.64 (s, 3H), 7.11 (dd, J = 5.1, 6.6 Hz, 1H), 7.47 (m, 1H), 7.49 (s, 1H), 7.55

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(d, J = 5.9 Hz, 1H), 7.67 (ddd, J = 1.7, 7.6, 7.8 Hz, 1H), 7.93 (d, J = 8.1 Hz, 1H), 8.32 (d, J = 4.1 Hz, 1H), 8.47 (s, 1H)
Mass spectrometric value (ESI-MS, m/z): 357 (M+Na)⁺

Example 33: 5,6-Dimethyl-3-(thieno[3,2-d]pyrimidin-4-yloxy)-[2,2']bipyridine (compound 33)

[0228] Formamide (4 ml) was added to methyl 3-amino-thiophene-2-carboxylate (400 mg), and the mixture was stirred with a microwave reactor at 220°C for 20 min. The above reaction was carried out using the same amount of starting materials by additional two batches. The reaction mixtures were cooled to room temperature and were combined together. Water was added thereto, and the organic layer was extracted with methanol/chloroform and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue (1.90 g) as such was used in the next reaction without further purification.

A part (400 mg) of the residue was suspended in diisopropylethylamine (2.29 ml). Phosphorus oxychloride (1.22 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. The solvent was removed by distillation under the reduced pressure. Water was then added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution. The organic layer was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4-chloro-thieno[3,2-d]pyrimidine (167 mg, yield 61%) (2 steps).

[0229] 4-Chloro-thieno[3,2-d]pyrimidine (35 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (41 mg), and 4-dimethylaminopyridine (75 mg) were dissolved in dimethylsulfoxide (1 ml). Cesium carbonate (229 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (64 mg, yield 91%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.64 (s, 3H), 7.09 (m, 1H), 7.50 (s, 1H), 7.53 (d, J = 5.4 Hz, 1H), 7.66 (ddd, J = 1.7, 7.8, 7.8 Hz, 1H), 7.96 (d, J = 5.6 Hz, 1H), 7.98 (s, 1H), 8.28 (d, J = 4.1 Hz, 1H), 8.58 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 357 (M+Na)⁺

Example 34: 5,6-Dimethyl-3-(5-methyl-thieno[2,3-d]pyrimidin-4-yloxy)-[2,2'] bipyridine (compound 34)

[0230] Formamide (4 ml) was added to methyl 2-amino-4-methyl-thiophene-3-carboxylate (400 mg), and the mixture was stirred with a microwave reactor at 220°C for 20 min. The above reaction was carried out using the same amount of starting materials by additional two batches. The reaction mixtures were cooled to room temperature and were combined together. Water was added thereto, and the organic layer was extracted with methanol/chloroform and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue (1.35 g) as such was used in the next reaction without further purification.

A part (300 mg) of the residue was suspended in diisopropylethylamine (1.57 ml). Phosphorus oxychloride (0.84 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. The solvent was removed by distillation under the reduced pressure. Water was then added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution. The organic layer was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4-chloro-5-methyl-thieno[2,3-d]pyrimidine (231 mg, yield 87%) (2 steps).

[0231] 4-Chloro-5-methyl-thieno[2,3-d]pyrimidine (35 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (38 mg), and 4-dimethylaminopyridine (69 mg) were dissolved in dimethylsulfoxide (1 ml). Cesium carbonate (185 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (46 mg, yield 70%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.56 (d, J = 1.2 Hz, 3H), 2.63 (s, 3H), 7.02 (d, J = 0.7 Hz, 1H), 7.11 (dd, J = 6.1, 6.3 Hz, 1H), 7.46 (s, 1H), 7.66 (dd, J = 7.6, 7.8 Hz, 1H), 7.89 (d, J = 8.1 Hz, 1H), 8.34 (d, J = 4.1 Hz, 1H), 8.44 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 371 (M+Na)⁺

Example 35: 3-(5,6-Dimethyl-thieno[2,3-d]pyrimidin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 35)

[0232] Ethyl 2-amino-4,5-dimethyl-thiophene-3-carboxylate (1.00 g) was suspended in formamide (5.0 ml), and the

suspension was stirred at 180°C for 15 hr. The reaction mixture was cooled to room temperature and was then filtered. The residue was washed with ethyl acetate and diethyl ether to give 5,6-dimethyl-1H-thieno[2,3-d]pyrimidin-4-one (689 mg, yield 71%).

5,6-Dimethyl-1H-thieno[2,3-d]pyrimidin-4-one (200 mg) was suspended in thionyl chloride (2.5 ml). N,N-Dimethylformamide (two drops) was added to the suspension, and the mixture was stirred at 110°C for 3 hr. The solvent was removed by distillation under the reduced pressure. Water was added to the residue, and the solution was rendered weakly basic by the addition of a saturated aqueous sodium hydrogencarbonate solution. Chloroform was added thereto for extraction, and the chloroform layer was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-hexane system to give 4-chloro-5,6-dimethyl-thieno[2,3-d]pyrimidine (205 mg, yield 93%).

[0233] 4-Chloro-5,6-dimethyl-thieno[2,3-d]pyrimidine (40 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (20 mg), and 4-dimethylaminopyridine (37 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the mixture was stirred at 140°C for 3 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (20 mg, yield 55%). ¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.43 (s, 3H), 2.48 (s, 3H), 2.61 (s, 3H), 7.09 (m, 1H), 7.43 (s, 1H), 7.64 (ddd, J = 7.6, 7.6, 2.0 Hz, 1H), 7.83 (d, J = 8.0 Hz, 1H), 8.35 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 385 (M+Na)⁺

Example 37: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-6-ethyl-[2,2']bipyridine (compound 37)

[0234] 2-Bromopyridine (500 mg) was dissolved in tetrahydrofuran (15 ml). A 1.58 M n-butyllithium/hexane solution (2 ml) was added to the solution at -78°C, and the mixture was stirred for 30 min. 5-Ethylfurfural (350 mg) was added to the reaction mixture, and the mixture was stirred at room temperature for additional one hr. Water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (5-ethyl-furan-2-yl)-pyridin-2-yl-methanol (214 mg, yield 37%).

(5-Ethyl-furan-2-yl)-pyridin-2-yl-methanol (214 mg) was dissolved in chloroform (5 ml). Manganese dioxide (1.37 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered, and the solvent was removed by distillation under the reduced pressure. The residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (5-ethyl-furan-2-yl)-pyridin-2-yl-methanone (161 mg, yield 76%).

(5-Ethyl-furan-2-yl)-pyridin-2-yl-methanone (160 mg) was dissolved in methanol (3 ml), 28% aqueous ammonia (3 ml) was added to the solution, and the mixture was stirred in a sealed tube at 160°C overnight. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-hexane system to give 6-ethyl-[2,2']bipyridinyl-3-ol (104 mg, yield 65%).

[0235] 4-Chloro-6,7-dimethoxyquinoline (167 mg), 6-ethyl-[2,2']bipyridinyl-3-ol (50 mg), and 4-dimethylaminopyridine (30.5 mg) were dissolved in dimethylsulfoxide (5 ml). Cesium carbonate (81.5 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-chloroform system to give the title compound (10 mg, yield 10%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.41 (t, J = 7.6 Hz, 3H), 3.00 (q, J = 7.6 Hz, 2H), 4.02 (s, 3H), 4.03 (s, 3H), 6.37 (d, J = 5.4 Hz, 1H), 7.13 (ddd, J = 1.0, 4.6, 7.6 Hz, 1H), 7.33 (d, J = 8.5 Hz, 1H), 7.37 (s, 1H), 7.54 (s, 1H), 7.55 (d, J = 7.6 Hz, 1H), 7.62 (ddd, J = 1.7, 7.8, 7.8 Hz, 1H), 7.82 (ddd, J = 1.0, 1.0, 8.0 Hz, 1H), 8.40 (d, J = 5.4 Hz, 1H), 8.48 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 410 (M+Na)⁺

Example 38: 4-(5,6,5'-Trimethyl-[2,2']bipyridin-3-yloxy)-quinazoline (compound 38)

[0236] 2-Bromo-5-picoline (1.5 g) was dissolved in anhydrous tetrahydrofuran (40 ml) under an argon atmosphere. A 1.6 M n-butyllithium/hexane solution (5.6 ml) was added dropwise to the solution at -78°C, and the mixture was stirred at -78°C for 30 min. 4,5-Dimethylfurfural (1 g) dissolved in anhydrous tetrahydrofuran (20 ml) was added dropwise to the reaction mixture, and the mixture was brought to room temperature with stirring. Water was added to the reaction mixture to stop the reaction. The solvent was removed by distillation under the reduced pressure, water was added to the residue, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the

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residue was purified by column chromatography with a hexane-ethyl acetate system to give (4,5-dimethylfuran-2-yl)-(5-methyl-pyridin-2-yl)-methanol (855 mg, yield 44%).

[0237] (4,5-Dimethylfuran-2-yl)-(5-methyl-pyridin-2-yl)-m ethanol (850 mg) was dissolved in chloroform (40 ml). Manganese dioxide (3.4 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered through Celite, and the solvent was removed from the filtrate by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-ethyl acetate system to give (4,5-dimethylfuran-2-yl)-(5-methyl-pyridin-2-yl)-methanone (788 mg, yield 93%).

(4,5-Dimethylfuran-2-yl)-(5-methyl-pyridin-2-yl)-m ethanone (780 mg), methanol (7 ml), and a 28% aqueous ammonia solution (7 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-ethyl acetate system to give 5,6,5'-trimethyl-[2,2']bipyridinyl-3-ol (529 mg, yield 68%).

[0238] Dimethylsulfoxide (1 ml) was added to 5,6,5'-trimethyl-[2,2']bipyridinyl-3-ol (20 mg), 4-chloroquinazoline (31 mg), and cesium carbonate (91 mg), and the mixture was stirred at 120°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (13 mg, yield 41%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.19 (s, 3H), 2.40 (s, 3H), 2.63 (s, 3H), 7.42 (d, J = 8.0 Hz, 1H), 7.46 (s, 1H), 7.64 (dd, J = 7.6, 7.6 Hz, 1H), 7.84 (d, J = 8.0 Hz, 1H), 7.90 (dd, J = 8.0, 8.0 Hz, 1H), 7.97 (d, J = 8.6 Hz, 1H), 8.02 (s, 1H), 8.37 (d, J = 8.0 Hz, 1H), 8.63 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 365 (M+Na)⁺

Example 39: 6-Methoxy-4-(5,6,5'-trimethyl-[2,2']bipyridin-3-yloxy)-quinazoline (compound 39)

[0239] 4-Chloro-6-methoxy-quinazoline (40 mg), 5,6,5'-trimethyl-[2,2']bipyridinyl-3-ol (44 mg), and 4-dimethylaminopyridine (75 mg) were dissolved in dimethylsulfoxide (1 ml). Cesium carbonate (201 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (49 mg, yield 63%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.22 (s, 3H), 2.41 (s, 3H), 2.63 (s, 3H), 3.98 (s, 3H), 7.45 (s, 1H), 7.47 (s, 1H), 7.53 (dd, J = 2.9, 9.3 Hz, 1H), 7.64 (d, J = 2.7 Hz, 1H), 7.84 (d, J = 8.1 Hz, 1H), 7.88 (d, J = 9.0 Hz, 1H), 8.11 (s, 1H), 8.51 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 395 (M+Na)⁺

Example 41: 6,7-Dimethoxy-4-(5,6,6'-trimethyl-[2,2']bipyridin-3-yloxy)-quinazoline (compound 41)

[0240] 2-Bromo-6-picoline (1.5 g) was dissolved in tetrahydrofuran (40 ml) under an argon atmosphere. A 1.6 M solution (5.6 ml) of n-butyllithium in hexane was added dropwise to the solution at -78°C, and the mixture was then stirred at -78°C for 30 min. 4,5-Dimethylfurfural (1 g) dissolved in tetrahydrofuran (20 ml) was added dropwise to the solution, and the mixture was brought to room temperature with stirring. Water was added to the reaction mixture to stop the reaction. The solvent was removed by distillation under the reduced pressure, water was added to the residue, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give (4,5-dimethylfuran-2-yl)-(6-methyl-pyridin-2-yl)-methanol (1.4 g, yield 74%).

(4,5-Dimethylfuran-2-yl)-(6-methyl-pyridin-2-yl)-m ethanol (1.4 g) was dissolved in chloroform (30 ml). Manganese dioxide (5.7 g) was added to the solution, and the mixture was stirred at room temperature overnight. Further, manganese dioxide (1.8 g) was added thereto, and the mixture was stirred overnight. The reaction mixture was filtered through Celite, and the solvent was removed from the filtrate by distillation under the reduced pressure to give (4,5-dimethylfuran-2-yl)-(6-methyl-pyridin-2-yl)-methanone (815 mg, yield 58%).

(4,5-Dimethylfuran-2-yl)-(6-methyl-pyridin-2-yl)-m ethanone (810 mg), methanol (7 ml), and a 28% aqueous ammonia solution (7 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-ethyl acetate system to give 5,6,6'-trimethyl-[2,2']bipyridinyl-3-ol (753 mg, yield 93%).

[0241] Dimethylsulfoxide (2 ml) was added to 5,6,6'-trimethyl-[2,2']bipyridinyl-3-ol (40 mg), 4-chloro-6,7-dimethoxy-

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quinazoline (126 mg), and cesium carbonate (183 mg), and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with

a chloroform-methanol system to give the title compound (22 mg, yield 29%).
¹H-NMR (CDCl₃, 400 MHz): δ 1.90 (s, 3H), 2.40 (s, 3H), 2.62 (s, 3H), 4.04 (s, 3H), 4.06 (s, 3H), 6.87 (d, J = 7.8 Hz, 1H), 7.29 (s, 1H), 7.47 (s, 1H), 7.51 (dd, J = 7.8, 7.8 Hz, 1H), 7.58 (s, 1H), 7.79 (d, J = 7.8 Hz, 1H), 8.45 (s, 1H)
Mass spectrometric value (ESI-MS, m/z): 425 (M+Na)⁺

Example 43: 5,6-Dimethyl-3-(quinolin-4-yloxy)-[2,3']bipyridine (compound 43)

[0242] 2,3-Dimethylfuran (5 g) was dissolved in diethyl ether (75 ml) under an argon atmosphere. A 1.6 M solution (35.7 ml) of n-butyllithium in hexane was added dropwise to the solution at 0°C, and the mixture was stirred under reflux for 2.5 hr. The reaction mixture was then cooled to -78°C, 3-cyanopyridine (6.0 g) dissolved in diethyl ether (20 ml) was added dropwise thereto, and the mixture was stirred at room temperature for 3 hr. The reaction mixture was poured into ice to stop the reaction and was adjusted to pH 5 by the addition of 2 M hydrochloric acid, followed by extraction with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give (4,5-dimethylfuran-2-yl)-(3-pyridyl)-methanone (1.9 g, yield 18%).

(4,5-Dimethylfuran-2-yl)-(3-pyridyl)-methanone (1.8 g), methanol (30 ml), and a 28% aqueous ammonia solution (30 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-ethyl acetate system to give 5,6-dimethyl-[2,3']-bipyridinyl-3-ol (1.1 g, yield 63%).

[0243] 1,2-Dichlorobenzene (2.5 ml) was added to 5,6-dimethyl-[2,3']-bipyridinyl-3-ol (50 mg), 4-chloroquinoline (123 mg), and 4-dimethylaminopyridine (92 mg), and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-acetone system to give the title compound (71 mg, yield 86%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.34 (s, 3H), 2.61 (s, 3H), 6.42 (d, J = 5.1 Hz, 1H), 7.19 (dd, J = 8.1, 4.9 Hz, 1H), 7.30 (s, 1H), 7.57 (ddd, J = 8.0, 6.8, 1.2 Hz, 1H), 7.74 (ddd, J = 8.6, 6.8, 1.8 Hz, 1H), 8.05 (d, J = 8.6 Hz, 1H), 8.16 (ddd, 8.1, 2.0, 2.0 Hz, 1H), 8.32 (dd, J = 8.5, 1.0 Hz, 1H), 8.45 (dd, J = 4.9, 1.7 Hz, 1H), 8.60 (d, J = 5.2 Hz, 1H), 9.12 (d, J = 1.7 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 328 (M+1)⁺

Example 44: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-5,6,2'-trimethyl-[2,3']bipyridine (compound 44)

[0244] 3-Bromo-2-methylpyridine (500 mg) was dissolved in tetrahydrofuran (15 ml). A 1.58 M solution (2 ml) of n-butyllithium/hexane was added to the solution at -78°C, and the mixture was stirred for 30 min. 4,5-Dimethylfurfural (350 mg) was added to the reaction mixture, and the mixture was stirred at room temperature for additional one hr. Water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (4,5-dimethyl-furan-2-yl)-(2-methyl-pyridin-3-yl)-methanol (251 mg, yield 40%).

(4,5-Dimethyl-furan-2-yl)-(2-methyl-pyridin-3-yl)-methanol (251 mg) was dissolved in chloroform (5 ml), manganese dioxide (1.51 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered, and the solvent was removed by distillation under the reduced pressure. The residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (4,5-dimethyl-furan-2-yl)-(2-methyl-pyridin-3-yl)-methanone (203 mg, yield 81%).

(4,5-Dimethyl-furan-2-yl)-(2-methyl-pyridin-3-yl)-methanone (203 mg) was dissolved in methanol (2 ml), 28% aqueous ammonia (2 ml) was added to the solution, and the mixture was stirred in a sealed tube at 160°C overnight. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-hexane system to give 5,6,2'-trimethoxy-[2,3']bipyridinyl-3-ol (12 mg, yield 6%).

[0245] 4-Chloro-6,7-dimethoxyquinoline (38 mg), 5,6,2'-trimethoxy-[2,3']bipyridinyl-3-ol (12 mg), and 4-dimethylaminopyridine (21 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 5 hr and further at 140°C for 2 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogen-carbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was

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removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (13 mg, yield 57%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.56 (s, 3H), 2.62 (s, 3H), 3.99 (s, 3H), 4.02 (s, 3H), 6.36 (d, J = 5.4 Hz, 1H), 7.00 (dd, J = 4.9, 7.3 Hz, 1H), 7.30 (s, 1H), 7.39 (s, 1H), 7.42 (s, 1H), 7.55 (dd, J = 1.7, 7.6 Hz, 1H), 8.36 (dd, J = 1.7, 4.9 Hz, 1H), 8.42 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 402 (M+1)⁺

Example 45: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-5'-methoxy-5,6-dimethyl-[2,3']bipyridine (compound 45)

[0246] 5-Bromo-3-methoxypyridine (500 mg) was dissolved in tetrahydrofuran (15 ml). A 1.58 M n-butyllithium/hexane solution (2 ml) was added to the solution at -78°C, and the mixture was stirred for 30 min. 4,5-Dimethylfurfural (350 mg) was added to the reaction mixture, and the mixture was stirred at room temperature for additional one hr. Water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (4,5-dimethyl-furan-2-yl)-(5-methoxy-pyridin-3-yl)-methanol (216 mg, yield 35%).

(4,5-Dimethyl-furan-2-yl)-(5-methoxy-pyridin-3-yl)-methanol (215 mg) was dissolved in chloroform (5 ml). Manganese dioxide (1.20 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered, and the solvent was removed by distillation under the reduced pressure. The residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (4,5-dimethyl-furan-2-yl)-(5-methoxy-pyridin-3-yl)-methanone (148 mg, yield 69%).

(4,5-Dimethyl-furan-2-yl)-(5-methoxy-pyridin-3-yl)-methanone (148 mg) was dissolved in methanol (1.5 ml), 28% aqueous ammonia (1.5 ml) was added to the solution, and the mixture was stirred in a sealed tube at 180°C overnight. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-hexane system to give 2'-methoxy-5,6-dimethyl-[2,3']bipyridinyl-3-ol (32 mg, yield 22%).

[0247] 4-Chloro-6,7-dimethoxyquinoline (92 mg), 2'-methoxy-5,6-dimethyl-[2,3']bipyridinyl-3-ol (31.5 mg), and 4-dimethylaminopyridine (50 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 140°C for 4.5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (48 mg, yield 83%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.38 (s, 3H), 2.64 (s, 3H), 3.75 (s, 3H), 4.04 (s, 3H), 4.06 (s, 3H), 6.37 (d, J = 5.4 Hz, 1H), 7.33 (s, 1H), 7.48 (s, 1H), 7.51 (s, 1H), 7.20 (m, 1H), 8.20 (d, J = 2.7 Hz, 1H), 8.43 (d, J = 5.4 Hz, 1H), 8.74 (d, J = 1.7 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 418 (M+1)⁺

Example 46: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-6-ethyl-[2,3']bipyridine (compound 46)

[0248] 3-Bromopyridine (500 mg) was dissolved in tetrahydrofuran (15 ml). A 1.58 M n-butyllithium/hexane solution (2 ml) was added to the solution at -78°C, and the mixture was stirred for 30 min. 5-Ethylfurfural (350 mg) was added to the reaction mixture, and the mixture was stirred at room temperature for additional one hr. Water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (5-ethyl-furan-2-yl)-pyridin-3-yl-methanol (209 mg, yield 33%).

(5-Ethyl-furan-2-yl)-pyridin-3-yl-methanol (209 mg) was dissolved in chloroform (5 ml), manganese dioxide (1.34 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered, and the solvent was removed by distillation under the reduced pressure. The residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (5-ethyl-furan-2-yl)-pyridin-3-yl-methanone (167 mg, yield 81%).

[0249] (5-Ethyl-furan-2-yl)-pyridin-3-yl-methanone (160 mg) was dissolved in methanol (2 ml), 28% aqueous ammonia (2 ml) was added to the solution, and the mixture was stirred in a sealed tube at 160°C for 2 days. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-hexane system to give 6-ethyl-[2,3']bipyridinyl-3-ol (72 mg, yield 45%).

6-Ethyl-[2,3']bipyridinyl-3-ol (20 mg), 4-chloro-6,7-dimethoxyquinoline (67 mg), and 4-dimethylamino-pyridine (37 mg) were dissolved in 1,2-dichlorobenzene (1 ml), and the solution was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-

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acetone system to give the title compound (16.3 mg, yield 42%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.42(t, J = 7.6 Hz, 3H), 2.97(q, J = 7.6 Hz, 2H), 4.03 (s, 3H), 4.04 (s, 3H), 6.38 (d, J = 5.4 Hz, 1H), 7.22 - 7.28 (m, 1H), 7.29 (s, 1H), 7.41 (s, 1H), 7.42 - 7.51 (m, 2H), 8.18 - 8.23 (m, 1H), 8.45 (d, J = 5.1 Hz, 1H), 8.52 (dd, J = 4.9, 1.7 Hz, 1H), 9.18 (d, J = 1.7 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 388 (M+1)⁺

Example 48: 4-(5,6-Dimethyl-[2,3']bipyridinyl-3-yloxy)-6,7-dimethoxy-quinazoline (compound 48)

[0250] 1,2-Dichlorobenzene (2.5 ml) was added to 5,6-dimethyl-[2,3']-bipyridinyl-3-ol (50 mg), 4-chloro-6,7-dimethoxyquinazoline (169 mg), and 4-dimethylaminopyridine (92 mg), and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (81 mg, yield 84%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.62 (s, 3H), 4.04 (s, 3H), 4.05 (s, 3H), 7.23 (ddd, J = 8.0, 4.9, 1.0 Hz, 1H), 7.29 (s, 1H), 7.45 (s, 1H), 7.47 (s, 1H), 8.09 (ddd, J = 7.8, 2.2, 2.2 Hz, 1H), 8.47 (dd, J = 4.9, 1.7 Hz, 1H), 8.55 (s, 1H), 9.04 (dd, J = 2.2, 0.8 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 411 (M+Na)⁺

Example 49: 4-(5,6-Dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (compound 49)

[0251] 2,3-Dimethylfuran (1.5 g) was dissolved in diethyl ether (20 ml) under an argon atmosphere. A 1.6 M n-butyl-lithium/hexane solution (10.9 ml) was added dropwise to the solution at 0°C, and the mixture was stirred under reflux for 2.5 hr. Thereafter, the reaction mixture was cooled to -78°C, 2-cyanopyrimidine (1.8 g) dissolved in diethyl ether (8 ml) was added dropwise to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was poured into ice to stop the reaction, was rendered acidic by the addition of 1 M hydrochloric acid, and was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give (4,5-dimethylfuran-2-yl)-(2-pyrimidyl)-methanone (226 mg, yield 7%).

[0252] (4,5-Dimethylfuran-2-yl)-(2-pyrimidyl)-methanone (220 mg), methanol (2 ml), and a 28% aqueous ammonia solution (2 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-acetone system to give 5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-ol (129 mg, yield 59%).

Dimethylsulfoxide (1.5 ml) was added to 5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-ol (30 mg), 4-chloroquinoline (73 mg), and cesium carbonate (146 mg), and the mixture was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (21 mg, yield 44%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 2.69 (s, 3H), 6.50 (d, J = 5.2 Hz, 1H), 7.08 (t, J = 4.9 Hz, 1H), 7.43 (s, 1H), 7.55 (ddd, J = 8.1, 6.8, 1.3 Hz, 1H), 7.73 (ddd, J = 8.3, 6.8, 1.3 Hz, 1H), 8.05 (d, J = 8.3 Hz, 1H), 8.34 (dd, J = 8.5, 1.0 Hz, 1H), 8.59 (d, J = 5.4 Hz, 1H), 8.62 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 329 (M+1)⁺

Example 50: 4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6,7-dimethoxy-quinoline (compound 50)

[0253] A 2.0 M lithium diisopropylamide/heptane, tetrahydrofuran, an ethylbenzene solution (26.2 ml), and tri-n-butyltin hydride (14.1 ml) were added in that order to anhydrous tetrahydrofuran (100 ml) under an argon atmosphere at 0°C, and the mixture was stirred at 0°C for 15 min. The reaction mixture was cooled to -78°C, and 2-chloropyrimidine (5.0 g) dissolved in anhydrous tetrahydrofuran (20 ml) was added dropwise to the cooled mixture. The mixture was slowly brought to room temperature and was stirred overnight. Water was added to the reaction mixture to stop the reaction. The mixture was filtered through Celite, and the filtrate was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give 2-tri-n-butylstannylpyrimidine (9.1 g, yield 56%).

[0254] 2-Tri-n-butylstannylpyrimidine (5.0 g) was dissolved in tetrahydrofuran (130 ml) under an argon atmosphere. A 1.6 M n-butyllithium/hexane solution (8.6 ml) was added dropwise to the solution at -78°C, and the mixture was stirred

at -78°C for 30 min. 4,5-Dimethylfurfural (1.85 g) dissolved in tetrahydrofuran (20 ml) was added dropwise thereto, and the mixture was brought to room temperature with stirring. Water was added to the reaction mixture to stop the reaction. The solvent was removed by distillation under the reduced pressure, water was added to the residue, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give (5-ethylfuran-2-yl)-pyrimidin-2-yl-methanol (888 mg, yield 32%).

(5-Ethylfuran-2-yl)-pyrimidin-2-yl-methanol (880 mg) was dissolved in chloroform (15 ml), manganese dioxide (3.8 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered through Celite, and the solvent was removed from the filtrate by distillation under the reduced pressure. The residue was used in the next reaction without purification.

[0255] The residue, methanol (7 ml), and a 28% aqueous ammonia solution (8 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-acetone system to give 6-ethyl-2-pyrimidin-2-yl-pyridin-3-ol (305 mg, yield 35%).

Dimethylsulfoxide (1.5 ml) was added to 6-ethyl-2-pyrimidin-2-yl-pyridin-3-ol (30 mg), 4-chloro-6,7-dimethoxyquinoline (101 mg), cesium carbonate (147 mg), and 4-dimethylaminopyridine (55 mg), and the mixture was stirred at 130°C overnight. 6-Ethyl-2-pyrimidin-2-yl-pyridin-3-ol (30 mg) was further added thereto, and the mixture was further stirred overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-acetone system. The mixture thus obtained was dissolved in ethyl acetate, and the solution was washed with a 1 N aqueous sodium hydroxide solution and water in that order to give the title compound (20 mg, yield 18%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.40(t, J = 7.8 Hz, 3H), 3.04 (q, J = 7.8 Hz, 2H), 4.02 (s, 3H), 4.03 (s, 3H), 6.44 (d, J = 5.4 Hz, 1H), 7.12 (t, J = 4.9 Hz, 1H), 7.38 (s, 1H), 7.42 (d, J = 8.5 Hz, 1H), 7.53 (s, 1H), 7.60 (d, J = 8.3 Hz, 1H), 8.41 (d, J = 5.1 Hz, 1H), 8.66 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 389 (M+1)⁺

Example 51: 4-(5,6-Dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6,7-dimethoxy-quinazoline (compound 51)

[0256] Dimethylsulfoxide (1.5 ml) was added to 5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-ol (30 mg), 4-chloro-6,7-dimethoxyquinazoline (73 mg), and cesium carbonate(146 mg), and the mixture was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (35 mg, yield 61%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.44 (s, 3H), 2.69 (s, 3H), 4.01 (s, 3H), 4.06 (s, 3H), 7.07(t, J = 4.9 Hz, 1H), 7.30 (s, 1H), 7.49 (s, 1H), 7.55 (s, 1H), 8.49 (s, 1H), 8.58 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 412 (M+Na)⁺

Example 52: 2-Phenyl-3-(quinolin-4-yloxy)-[1,8]naphthyridine (compound 52)

[0257] 2-Aminopyridine-3-carbaldehyde (5.00 g) and 2-chloro-1-phenyl-ethanone (7.27 g) were suspended in a 5 N aqueous sodium hydroxide solution (45.0 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 2-phenyl-[1,8]naphthyridin-3-ol (5.8 g, yield 64%).

2-Phenyl-[1,8]naphthyridin-3-ol(10 mg), 4-chloroquinoline (22 mg), and 4-dimethylaminopyridine (17 mg) were dissolved in 1,2-dichlorobenzene (0.5 ml), and the mixture was stirred at 120°C overnight. The reaction mixture was cooled to room temperature, water was added thereto, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (8.3 mg, yield 53%).

¹H-NMR (CDCl₃, 400 MHz): δ 6.54 (d, J = 5.1 Hz, 1H), 7.32 - 7.34 (m, 3H), 7.53 (dd, J = 8.3, 4.4 Hz, 1H), 7.59 - 7.66 (m, 1H), 7.79 (ddd, J = 8.3, 6.8, 1.2 Hz, 1H), 7.96 (s, 1H), 8.11 (d, J = 8.5 Hz, 1H), 8.13 - 8.20 (m, 3H), 8.36 (d, J = 7.6 Hz, 1H), 8.65 (d, J = 5.1 Hz, 1H), 9.18 (dd, J = 4.1, 1.9 Hz, 1H)

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Mass spectrometric value (ESI-MS, m/z): 372 (M+Na)⁺

Example 53: 3-(6-Fluoro-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 53)

5 **[0258]** 2-phenyl-[1,8]naphthyridin-3-ol (61 mg), 4-chloro-6-fluoroquinoline (50 mg), and 4-dimethylaminopyridine (101 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the mixture was stirred at 130 °C for 4 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (99 mg, yield 97%).

10 ¹H-NMR (CDCl₃, 400 MHz): δ 6.53 (d, J = 5.4 Hz, 1H), 7.32 - 7.36 (m, 3H), 7.55 - 7.62 (m, 2H), 8.00 (dd, J = 2.7, 9.0 Hz, 1H), 8.02 (s, 1H), 8.09 (m, 2H), 8.20 - 8.22 (m, 2H), 8.59 (d, J = 5.4 Hz, 1H), 9.21 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 390 (M+Na)⁺

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Example 54: 2-Phenyl-3-(6-trifluoromethyl-quinolin-4-yloxy)-[1,8]naphthyridine (compound 54)

20 **[0259]** 2-Phenyl-[1,8]naphthyridin-3-ol (48 mg), 4-chloro-6-trifluoromethylquinoline (50 mg), and 4-dimethylaminopyridine (79 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130 °C for 4.5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (88 mg, yield 96%).

25 ¹H-NMR (CDCl₃, 400 MHz): δ 6.52 (d, J = 5.4 Hz, 1H), 7.30 - 7.34 (m, 3H), 7.58 (dd, J = 4.1, 8.1 Hz, 1H), 7.97 (dd, J = 2.2, 9.0 Hz, 1H), 8.06 - 8.09 (m, 2H), 8.08 (s, 1H), 8.24 (m, 2H), 8.69 (d, J = 5.4 Hz, 1H), 8.74 (s, 1H), 9.22 (dd, J = 2.0, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 440 (M+Na)⁺

Example 55: 3-(6-Methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 55)

35 **[0260]** 2-Phenyl-[1,8]naphthyridin-3-ol (72 mg), 4-chloro-6-methoxyquinoline (72 mg), and 4-dimethylaminopyridine (90 mg) were suspended in 1,2-dichlorobenzene (4 ml), and the mixture was stirred at 150 °C for 4 hr. Further, 4-chloro-6,7-dimethoxyquinoline (72 mg) was added thereto, and the mixture was stirred at 150 °C for 5 hr. The reaction mixture was cooled to room temperature, the solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give the title compound (105 mg, yield 85%).

40 ¹H-NMR (CDCl₃, 400 MHz): δ 3.94 (s, 3H), 6.59 (d, J = 5.2 Hz, 1H), 7.36 - 7.39 (m, 3H), 7.43 (dd, J = 2.9, 9.3 Hz, 1H), 7.51 - 7.54 (m, 2H), 7.93 (s, 1H), 8.02 (d, J = 9.2 Hz, 1H), 8.14 - 8.18 (m, 3H), 8.54 (d, J = 5.1 Hz, 1H), 9.17 (dd, J = 1.9, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 402 (M+Na)⁺

Example 56: 3-(7-Methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 56)

45 **[0261]** 2-Phenyl-[1,8]naphthyridin-3-ol (84 mg), 4-chloro-7-methoxyquinoline (84 mg), and 4-dimethylaminopyridine (158 mg) were suspended in 1,2-dichlorobenzene (4 ml), and the suspension was stirred at 140 °C for 7 hr. The reaction mixture was cooled to room temperature, the solvent was then removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (105 mg, yield 73%).

50 ¹H-NMR (CDCl₃, 400 MHz): δ 3.97 (s, 3H), 6.42 (d, J = 5.1 Hz, 1H), 7.24 (d, J = 2.4 Hz, 1H), 7.34 - 7.37 (m, 3H), 7.42 (d, J = 2.4 Hz, 1H), 7.52 (dd, J = 4.4, 8.3 Hz, 1H), 7.93 (s, 1H), 8.12 - 8.17 (m, 3H), 8.22 (d, J = 9.0 Hz, 1H), 8.57 (d, J = 5.4 Hz, 1H), 9.17 (dd, J = 1.9, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 402 (M+Na)⁺

Example 57: 3-(5,6-Dichloro-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 57)

55 **[0262]** 3,4-Dichloroaniline (1.65 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.95 g) were dissolved in diphenyl ether (20 ml), and the solution was stirred at 70 °C for 30 min. Biphenyl (5.2 g) was added to the

reaction mixture, and the mixture was stirred at 220°C for additional one hr. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with chloroform. The crystal thus obtained as such was used in the next reaction without further purification.

The residue was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (1 ml) was added to the solution, and the mixture was stirred at 100°C for one hr. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give 4,5,6-trichloroquinoline (176 mg, yield 7%) (3 steps) and 4,6,7-trichloroquinoline (113 mg, yield 5%) (3 steps).

[0263] 4,5,6-Trichloroquinoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (48 mg), and 4-dimethylaminopyridine (79 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the mixture was stirred at 130°C for 2 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (69 mg, yield 75%).

¹H-NMR (CDCl₃, 400 MHz): δ 6.62 (d, J = 5.1 Hz, 1H), 7.34 - 7.41 (m, 3H), 7.53 (dd, J = 4.1, 8.1 Hz, 1H), 7.83 (s, 1H), 7.83 (d, J = 9.0 Hz, 1H), 8.02 (d, J = 9.0 Hz, 1H), 8.15 (dd, J = 2.0, 8.3 Hz, 1H), 8.22 (m, 2H), 8.61 (d, J = 5.1 Hz, 1H), 9.17 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 440 (M+Na)⁺

Example 58: 3-(6,7-Dichloro-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 58)

[0264] 4,6,7-Trichloroquinoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (48 mg), and 4-dimethylaminopyridine (79 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the mixture was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (86 mg, yield 94%).

¹H-NMR (CDCl₃, 400 MHz): δ 6.45 (d, J = 5.4 Hz, 1H), 7.33 - 7.37 (m, 3H), 7.57 (dd, J = 4.4, 8.3 Hz, 1H), 8.03 (s, 1H), 8.07 (m, 2H), 8.22 (dd, J = 2.0, 8.2 Hz, 1H), 8.25 (s, 1H), 8.49 (s, 1H), 8.58 (d, J = 5.4 Hz, 1H), 9.21 (dd, J = 2.2, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 440 (M+Na)⁺

Example 59: 3-(6-Fluoro-7-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 59)

[0265] 4-Fluoro-3-methoxyaniline (1.0 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.62 g) were suspended in 2-propanol (40 ml), and the mixture was stirred at 70°C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with methanol and then with ether. The crystal thus obtained as such was used in the next reaction without further purification.

The crystal prepared above and biphenyl (6.1 g) were suspended in diphenyl ether (25 ml), and the suspension was stirred at 220°C for one hr. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with chloroform. The crystal thus obtained as such was used in the next reaction without further purification.

The residue was suspended in diisopropylethylamine (7 ml). Phosphorus oxychloride (2 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 4-chloro-6-fluoro-7-methoxy-quinoline (550 mg, yield 37%) (3 steps).

[0266] 4-Chloro-6-fluoro-7-methoxy-quinoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (53 mg), and 4-dimethylaminopyridine (87 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 6 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (78 mg, yield 82%).

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¹H-NMR (CDCl₃, 400 MHz): δ 4.07 (s, 3H), 6.44 (d, J = 5.6 Hz, 1H), 7.33 - 7.36 (m, 3H), 7.56 (dd, J = 4.1, 8.1 Hz, 1H), 7.66 (m, 1H), 7.98 (d, J = 11.2 Hz, 1H), 8.01 (s, 1H), 8.07 (m, 2H), 8.20 (dd, J = 2.0, 8.3 Hz, 1H), 8.51 (d, J = 5.4 Hz, 1H), 9.20 (dd, J = 2.2, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 420 (M+Na)⁺

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Example 60: 3-(7-Fluoro-6-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 60)

[0267] 3-Fluoro-4-methoxyaniline (1.41 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.00 g) were suspended in 2-propanol (40 ml), and the mixture was stirred at 70°C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with methanol and then with ether. The crystal thus obtained as such was used in the next reaction without further purification.

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The crystal prepared above and biphenyl (5.8 g) were suspended in diphenyl ether (20 ml), and the suspension was stirred at 220°C for one hr. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with chloroform. The crystal thus obtained as such was used in the next reaction without further purification.

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The residue was suspended in diisopropylethylamine (8 ml), phosphorus oxychloride (2 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate hexane system to give 4-chloro-7-fluoro-6-methoxy-quinoline (1.10 g, yield 52%) (3 steps).

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[0268] 4-Chloro-7-fluoro-6-methoxy-quinoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (53 mg), and 4-dimethylaminopyridine (87 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 8 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (48 mg, yield 50%).

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¹H-NMR (CDCl₃, 400 MHz): δ 4.06 (s, 3H), 6.56 (d, J = 5.4 Hz, 1H), 7.35 - 7.37 (m, 3H), 7.57 (dd, J = 4.1, 8.1 Hz, 1H), 7.65 (d, J = 8.8 Hz, 1H), 7.89 (d, J = 11.0 Hz, 1H), 8.02 (s, 1H), 8.09 (m, 2H), 8.20 (dd, J = 1.7, 8.1 Hz, 1H), 8.52 (d, J = 5.4 Hz, 1H), 9.20 (dd, J = 2.0, 4.1 Hz, 1H)

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Mass spectrometric value (ESI-MS, m/z): 420 (M+Na)⁺

Example 61: 3-(7-Chloro-6-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 61)

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[0269] 3-Chloro-4-methoxyaniline (1.52 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.03 g) were suspended in 2-propanol (40 ml), and the suspension was stirred at 70°C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was then collected by filtration and was washed with methanol and then with ether. The crystal thus obtained as such was used in the next reaction without further purification.

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The crystal prepared above and biphenyl (6.8 g) were suspended in diphenyl ether (20 ml), and the suspension was stirred at 220°C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with chloroform. The crystal thus obtained as such was used in the next reaction without further purification.

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The residue was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (1 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 4,7-dichloro-6-methoxy-quinoline (225 mg, yield 10%) (3 steps).

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[0270] 4,7-Dichloro-6-methoxy-quinoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (49 mg), and 4-dimethylaminopyridine (80 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 8 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (25 mg, yield 27%).

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¹H-NMR (CDCl₃, 400 MHz): δ 4.07 (s, 3H), 6.57 (d, J = 5.4 Hz, 1H), 7.32 - 7.38 (m, 3H), 7.57 (dd, J = 4.1, 8.1 Hz, 1H), 7.62 (s, 1H), 8.04 (s, 1H), 8.08 (m, 2H), 8.21 (dd, J = 1.7, 8.1 Hz, 1H), 8.29 (m, 1H), 8.51 (m, 1H), 9.21 (dd, J = 1.7, 4.1

Hz, 1H) Mass spectrometric value (ESI-MS, m/z): 436 (M+Na)⁺

Example 62: 3-(6-Methoxy-7-methyl-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 62)

5 **[0271]** 2-Bromomethyl-1-methoxy-4-nitrobenzene (2.03 g) was dissolved in N,N-dimethylformamide (30 ml). Triethylamine (5 ml) and 20% palladium hydroxide (1.08 g) were added to the solution, and the mixture was stirred under a hydrogen gas atmosphere at room temperature overnight. The reaction mixture was filtered and was then washed with chloroform. The solvent was removed by distillation under the reduced pressure, water was added to the residue, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without purification.

10 The residue and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.00 g) were suspended in 2-propanol (40 ml), and the suspension was stirred at 70°C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was then collected by filtration and was washed with methanol and then with ether. The crystal thus obtained as such was used in the next reaction without further purification.

15 The crystal prepared above and biphenyl (5.9 g) were suspended in diphenyl ether (15 ml), and the suspension was stirred at 220°C for 3 hr. The reaction mixture was cooled to room temperature, and the cooled reaction mixture as such was purified by column chromatography with an ethyl acetate-hexane system to give 6-methoxy-7-methyl-1H-quinolin-4-one (352 mg, yield 23%) (3 steps).

20 **[0272]** 6-Methoxy-7-methyl-1H-quinolin-4-one (352 mg) was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (1 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 4-chloro-6-methoxy-7-methyl-quinoline (234 mg, yield 61%).

25 4-Chloro-6-methoxy-7-methyl-quinoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (54 mg), and 4-dimethylaminopyridine (88 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 7.5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (71 mg, yield 75%).

30 ¹H-NMR (CDCl₃, 400 MHz): δ 2.45 (s, 3H), 3.96 (s, 3H), 6.57 (d, J = 5.4 Hz, 1H), 7.35 - 7.39 (m, 3H), 7.44 (s, 1H), 7.53 (dd, J = 4.1, 8.1 Hz, 1H), 7.94 (s, 1H), 7.94 (s, 1H), 8.15 - 8.17 (m, 3H), 8.50 (d, J = 5.4 Hz, 1H), 9.17 (dd, J = 2.0, 4.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 416 (M+Na)⁺

Example 63: Methyl 7-methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylate (compound 63)

40 **[0273]** Methyl 4-chloro-7-methoxy-quinoline-6-carboxylate (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (44 mg) and 4-dimethylaminopyridine (73 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 4.5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (70 mg, yield 80%).

45 ¹H-NMR (CDCl₃, 400 MHz): δ 4.00 (s, 3H), 4.05 (s, 3H), 6.35 (a, J = 5.4 Hz, 1H), 7.32 - 7.35 (m, 3H), 7.52 (s, 1H), 7.56 (dd, J = 4.1, 8.1 Hz, 1H), 8.02 (s, 1H), 8.10 (m, 2H), 8.21 (dd, J = 2.0, 8.1 Hz, 1H), 8.57 (d, J = 5.4 Hz, 1H), 8.80 (s, 1H), 9.20 (dd, J = 2.0, 4.1 Hz, 1H)

50 Mass spectrometric value (ESI-MS, m/z): 460 (M+Na)⁺

Example 65: 7-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylate benzylamide (compound 65)

55 **[0274]** Methyl 7-methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylate (compound 63) (206 mg) was dissolved in ethanol/water (4 ml/0.4 ml). Lithium hydroxide monohydrate (99 mg) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was neutralized with hydrochloric acid. The solvent was then removed by distillation under the reduced pressure, and the residue (334 mg) as such was used in the next reaction without purification.

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A part (271 mg) of the residue, benzylamine (62 μ l), and 1-ethyl-3-(3-dimethylaminopropylcarbodiimide hydrochloride (370 mg), and 1-hydroxybenzotriazole hydrate (216 mg) were dissolved in N,N-dimethylformamide (3 ml), and the solution was stirred at room temperature overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol/chloroform system to give the title compound (187 mg, yield 96%) (2 steps).

$^1\text{H-NMR}$ (CDCl_3 , 400 MHz): δ 4.08 (s, 3H), 4.78 (d, J = 5.6 Hz, 2H), 6.29 (d, J = 5.4 Hz, 1H), 7.33 - 7.44 (m, 8H), 7.53 (s, 1H), 7.55 (dd, J = 4.1, 8.1 Hz, 1H), 8.03 (s, 1H), 8.13 (m, 2H), 8.21 (dd, J = 2.0, 8.3 Hz, 1H), 8.25 (dd, J = 5.4, 5.6 Hz, 1H), 8.53 (d, J = 5.4 Hz, 1H), 9.19 (dd, J = 2.2, 4.4 Hz, 1H), 9.37 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 535 (M+Na)⁺

Example 66: 7-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylic acid amide (compound 66)

[0275] Methyl 7-methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylate (compound 63) (46 mg) was dissolved in methanol (2 ml), 28% aqueous ammonia (2 ml) was added to the solution, and the mixture was stirred at 40°C overnight. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (36 mg, yield 77%).

$^1\text{H-NMR}$ (CDCl_3 , 400 MHz): δ 4.14 (s, 3H), 5.97 (brs, 1H), 6.30 (d, J = 5.4 Hz, 1H), 7.28 - 7.33 (m, 3H), 7.56 (dd, J = 4.4, 8.3 Hz, 1H), 7.60 (s, 1H), 7.81 (brs, 1H), 8.05 (s, 1H), 8.11 (m, 2H), 8.22 (dd, J = 1.7, 8.1 Hz, 1H), 8.54 (d, J = 5.4 Hz, 1H), 9.20 (dd, J = 2.0, 4.1 Hz, 1H), 9.36 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 445 (M+Na)⁺

Example 68: 6-Chloro-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinazoline (compound 68)

[0276] 4,6-Dichloro-quinazoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (56 mg), and 4-dimethylaminopyridine (92 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 2 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (83 mg, yield 87%).

$^1\text{H-NMR}$ (CDCl_3 , 400 MHz): δ 7.30 - 7.34 (m, 3H), 7.56 (dd, J = 4.4, 8.3 Hz, 1H), 7.86 (dd, J = 2.2, 8.8 Hz, 1H), 7.94 (d, J = 9.0 Hz, 1H), 7.98 (m, 2H), 8.22 (s, 1H), 8.27 (dd, J = 2.0, 8.1 Hz, 1H), 8.33 (d, J = 2.2 Hz, 1H), 8.60 (s, 1H), 9.19 (dd, J = 2.0, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 407 (M+Na)⁺

Example 69: 6-Bromo-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinazoline (compound 69)

[0277] 6-Bromo-4-chloro-quinazoline (100 mg), 2-phenyl-[1,8]naphthyridin-3-ol (91 mg), and 4-dimethylaminopyridine (151 mg) were suspended in 1,2-dichlorobenzene (2 ml), and the suspension was stirred at 130°C for 2 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (165 mg, yield 94%).

$^1\text{H-NMR}$ (CDCl_3 , 400 MHz): δ 7.30 - 7.36 (m, 3H), 7.57 (dd, J = 4.4, 8.3 Hz, 1H), 7.86 (d, J = 8.8 Hz, 1H), 7.96 - 8.01 (m, 3H), 8.23 (s, 1H), 8.28 (dd, J = 2.0, 8.3 Hz, 1H), 8.51 (d, J = 2.2 Hz, 1H), 8.62 (s, 1H), 9.20 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 451 (M+Na)⁺

Example 70: 6-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinazoline (compound 70)

[0278] 4-Chloro-6-methoxy-quinazoline (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (57 mg), and 4-dimethylaminopyridine (94 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 2 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system

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to give the title compound (92 mg, yield 93%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.97 (s, 3H), 7.30 - 7.34 (m, 3H), 7.52 (d, J = 2.7 Hz, 1H), 7.55 - 7.58 (m, 2H), 7.93 (d, J = 9.0 Hz, 1H), 8.01 (m, 2H), 8.28 (dd, J = 2.0, 6.1 Hz, 1H), 8.32 (s, 1H), 8.56 (s, 1H), 9.19 (dd, J = 2.0, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 403 (M+Na)⁺

5

Example 71: 2-Phenyl-3-(thieno[3,2-b]pyridin-7-yloxy)-[1,8]naphthyridine (compound 71)

[0279] 7-chloro-thieno[3,2-b]pyridine (29 mg), 2-phenyl-[1,8]naphthyridin-3-ol (38 mg), and 4-dimethylaminopyridine (63 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 16 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (25 mg, yield 41%).

10

¹H-NMR (CDCl₃, 400 MHz): δ 6.56 (d, J = 5.6 Hz, 1H), 7.36 - 7.38 (m, 3H), 7.56 (dd, J = 4.4, 8.2 Hz, 1H), 7.70 (d, J = 5.1 Hz, 1H), 7.85 (d, J = 5.1 Hz, 1H), 8.03 (s, 1H), 8.11 (m, 2H), 8.20 (dd, J = 2.0, 8.3 Hz, 1H), 8.46 (d, J = 5.9 Hz, 1H), 9.20 (dd, J = 2.0, 4.1 Hz, 1H)

15

Mass spectrometric value (ESI-MS, m/z): 378 (M+Na)⁺

20

Example 72: 2-Phenyl-3-(2-phenyl-thieno[3,2-b]pyridin-7-yloxy)-[1,8]naphthyridine (compound 72)

[0280] 7-Chloro-2-phenyl-thieno[3,2-b]pyridine (50 mg), 2-phenyl-[1,8]naphthyridin-3-ol (45 mg), and 4-dimethylaminopyridine (75 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 18 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (46 mg, yield 53%).

25

¹H-NMR (CDCl₃, 400 MHz): δ 6.54 (dd, J = 0.5, 5.6 Hz, 1H), 7.36 - 7.50 (m, 6H), 7.55 (ddd, J = 1.0, 4.2, 8.1 Hz, 1H), 7.75 (d, J = 7.3 Hz, 2H), 7.83 (s, 1H), 8.01 (s, 1H), 8.15 (m, 2H), 8.19 (dd, J = 1.7, 8.1 Hz, 1H), 8.43 (d, J = 5.6 Hz, 1H), 9.19 (m, 1H)

30

Mass spectrometric value (ESI-MS, m/z): 454 (M+Na)⁺

Example 73: 4-(2-Phenyl-[1,8]naphthyridin-3-yloxy)-[1,5]naphthyridine (compound 73)

[0281] 4-Chloro-[1,5]naphthyridine (15 mg), 2-phenyl-[1,8]naphthyridin-3-ol (40 mg), and 4-dimethylaminopyridine (33 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 3.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (11 mg, yield 35%).

35

¹H-NMR (CDCl₃, 400 MHz): δ 6.64 (d, J = 5.2 Hz, 1H), 7.26 (m, 3H), 7.52 (dd, J = 8.0, 4.4 Hz, 1H), 7.72 (dd, J = 8.8, 4.0 Hz, 1H), 8.00 (s, 1H), 8.17 (dd, J = 8.0, 2.0 Hz, 1H), 8.24 (m, 2H), 8.39 (dd, J = 8.8, 2.0 Hz, 1H), 8.63 (d, J = 5.2 Hz, 1H), 9.04 (dd, J = 4.0, 2.4 Hz, 1H), 9.16 (dd, J = 4.0, 2.0 Hz, 1H)

40

Mass spectrometric value (ESI-MS, m/z): 373 (M+Na)⁺

45

Example 74: 4-(2-Phenyl-[1,8]naphthyridin-3-yloxy)-[1,6]naphthyridine (compound 74)

[0282] 4-Chloro-[1,6]naphthyridine (25 mg), 2-phenyl-[1,8]naphthyridin-3-ol (34 mg), and 4-dimethylaminopyridine (56 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 2 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (53 mg, yield 100%).

50

¹H-NMR (CDCl₃, 400 MHz): δ 6.48 (d, J = 5.1 Hz, 1H), 7.31 - 7.34 (m, 3H), 7.59 (dd, J = 4.4, 8.3 Hz, 1H), 7.91 (dd, J = 0.7, 5.9 Hz, 1H), 8.09 (m, 2H), 8.12 (s, 1H), 8.25 (dd, J = 2.0, 8.1 Hz, 1H), 8.74 (d, J = 5.4 Hz, 1H), 8.84 (d, J = 6.1 Hz, 1H), 9.23 (dd, J = 2.0, 4.4 Hz, 1H), 9.86 (d, J = 0.7 Hz, 1H)

55

Mass spectrometric value (ESI-MS, m/z): 373 (M+Na)⁺

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Example 75: 2-Phenyl-3-(thieno[3,2-d]pyrimidin-4-yloxy)-[1,8]naphthyridine (compound 75)

[0283] 4-Chloro-thieno[3,2-d]pyrimidine (35 mg), 2-phenyl-[1,8]naphthyridin-3-ol (46 mg), and 4-dimethylaminopyridine (75 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 2 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (65 mg, yield 86%).

¹H-NMR (CDCl₃, 400 MHz): δ 7.29 - 7.36 (m, 3H), 7.55 (d, J = 5.4 Hz, 1H), 7.57 (dd, J = 4.4, 8.1 Hz, 1H), 7.99 (d, J = 5.4 Hz, 1H), 8.04 (m, 2H), 8.26 (s, 1H), 8.28 (dd, J = 2.0, 8.3 Hz, 1H), 8.58 (s, 1H), 9.19 (dd, J = 2.0, 4.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 379 (M+Na)⁺

Example 76: 2-Phenyl-3-(thieno[2,3-d]pyrimidin-4-yloxy)-[1,8]naphthyridine (compound 76)

[0284] 4-Chloro-thieno[2,3-d]pyrimidine (40 mg), 2-phenyl-[1,8]naphthyridin-3-ol (52 mg), and 4-dimethylaminopyridine (86 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 2.5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (79 mg, yield 96%).

¹H-NMR (CDCl₃, 400 MHz): δ 7.31 - 7.34 (m, 3H), 7.53 - 7.57 (m, 3H), 8.02 (m, 2H), 8.23 (s, 1H), 8.27 (dd, J = 2.0, 8.1 Hz, 1H), 8.49 (s, 1H), 9.18 (dd, J = 2.0, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 379 (M+Na)⁺

Example 77: 3-(5-Methyl-thieno[2,3-d]pyrimidin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 77)

[0285] 4-Chloro-5-methyl-thieno[2,3-d]pyrimidine (32 mg), 2-phenyl-[1,8]naphthyridin-3-ol (39 mg), and 4-dimethylaminopyridine (64 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 130°C for 2.5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (62 mg, yield 99%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.61 (d, J = 1.2 Hz, 3H), 7.09 (d, J = 1.5 Hz, 1H), 7.31 - 7.35 (m, 3H), 7.54 (dd, J = 4.1, 8.1 Hz, 1H), 7.92 (m, 2H), 8.15 (s, 1H), 8.25 (dd, J = 1.7, 8.1 Hz, 1H), 8.42 (s, 1H), 9.17 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 371 (M+1)⁺

Example 78: 3-(5,6-Dimethyl-thieno[2,3-d]pyrimidin-4-yloxy)-2-phenyl-[1,8] naphthyridine (compound 78)

[0286] 4-Chloro-5,6-dimethyl-thieno[2,3-d]pyrimidine (15 mg), 2-phenyl-[1,8]naphthyridin-3-ol (25 mg), and 4-dimethylaminopyridine (28 mg) were suspended in 1,2-dichlorobenzene (2.0 ml), and the suspension was stirred at 140°C for 1 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (32 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.47 (s, 3H), 2.49 (s, 3H), 7.32 (m, 3H), 7.51 (dd, J = 8.0, 4.4 Hz, 1H), 7.92 (m, 2H), 8.11 (s, 1H), 8.22 (dd, J = 8.0, 1.6 Hz, 1H), 8.35 (s, 1H), 9.14 (dd, J = 8.0, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 407 (M+Na)⁺

Example 81: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-(3-methoxy-phenyl)-[1,8] naphthyridine compound 81)

[0287] 2-Aminopyridine-3-carbaldehyde (100 mg) and 2-bromo-1-(3-methoxy-phenyl)-ethanone (188 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was

purified by column chromatography with a chloroform-methanol system to give 2-(3-methoxy-phenyl)-[1,8]naphthyridin-3-ol (29 mg, yield 14%).

2-(3-Methoxy-phenyl)-[1,8]naphthyridin-3-ol (29 mg), 4-chloro-6,7-dimethoxyquinoline (64 mg), and 4-dimethylaminopyridine (42 mg) were suspended in 1,2-dichlorobenzene (2.0 ml), and the suspension was stirred at 140°C for 4 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (24 mg, yield 46%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.72 (s, 3H), 4.00 (s, 3H), 4.03 (s, 3H), 6.47 (d, J = 5.2 Hz, 1H), 6.99 (m, 1H), 7.23 (m, 1H), 7.42 (s, 1H), 7.49 (m, 2H), 7.70 (m, 2H), 7.93 (s, 1H), 8.14 (dd, J = 8.0, 2.0 Hz, 1H), 8.47 (d, J = 5.2 Hz, 1H), 9.15 (dd, J = 4.0, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 462 (M+Na)⁺

Example 82: 2-(4-Bromo-phenyl)-3-(quinolin-4-yloxy)-[1,8]naphthyridine (compound 82)

[0288] 2-Aminopyridine-3-carbaldehyde (100 mg) and 2-bromo-1-(4-bromo-phenyl)-ethanone (228 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 2-(4-bromo-phenyl)-[1,8]naphthyridin-3-ol (28 mg, yield 11%).

2-(4-Bromo-phenyl)-[1,8]naphthyridin-3-ol (13 mg), 4-chloroquinoline (21 mg), and 4-dimethylaminopyridine (16 mg) were suspended in 1,2-dichlorobenzene (1.0 ml), and the suspension was stirred at 140°C for 3.0 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (11 mg, yield 60%).

¹H-NMR (CDCl₃, 400 MHz): δ 6.54 (d, J = 5.2 Hz, 1H), 7.48 (m, 2H), 7.55 (dd, J = 8.0, 4.0 Hz, 1H), 7.74 (dd, J = 6.8, 6.8 Hz, 1H), 7.82 (dd, J = 6.8, 6.8 Hz, 1H), 7.95 (s, 1H), 8.06 (m, 2H), 8.15 (m, 2H), 8.32 (dd, J = 8, 4, 8.0 Hz, 1H), 8.67 (d, J = 5.2 Hz, 1H), 9.17 (dd, J = 4.4, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 450 (M+Na)⁺

Example 83: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-(4-fluoro-phenyl)-[1,8]naphthyridine (compound 83)

[0289] 2-Aminopyridine-3-carbaldehyde (100 mg) and 2-bromo-1-(4-fluoro-phenyl)-ethanone (178 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 2-(4-fluoro-phenyl)-[1,8]naphthyridin-3-ol (11 mg, yield 6%).

2-(4-Fluoro-phenyl)-[1,8]naphthyridin-3-ol (14 mg), 4-chloro-6,7-dimethoxyquinoline (39 mg), and 4-dimethylaminopyridine (21 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 9 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (14 mg, yield 57%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.01 (s, 3H), 4.06 (s, 3H), 6.50 (d, J = 5.2 Hz, 1H), 7.04 (m, 2H), 7.46 (s, 1H), 7.48 (s, 1H), 7.53 (dd, J = 8.0, 4.4 Hz, 1H), 7.92 (s, 1H), 8.18 (m, 3H), 8.49 (d, J = 5.2 Hz, 1H), 9.16 (dd, J = 4.0, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 450 (M+Na)⁺

Example 84: 2-(4-Chloro-phenyl)-3-(6,7-dimethoxy-quinolin-4-yloxy)-[1,8]naphthyridine (compound 84)

[0290] 2-Aminopyridine-3-carbaldehyde (100 mg) and 2-chloro-1-(4-chloro-phenyl)-ethanone (155 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was

dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 2-(4-chloro-phenyl)-[1,8]naphthyridin-3-ol (51 mg, yield 24%).

2-(4-Chloro-phenyl)-[1,8]naphthyridin-3-ol (48 mg), 4-chloro-6,7-dimethoxyquinoline (125 mg), and 4-dimethylaminopyridine (69 mg) were suspended in 1,2-dichlorobenzene (2.0 ml), and the suspension was stirred at 140°C for 4 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (40 mg, yield 47%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.99 (s, 3H), 4.04 (s, 3H), 6.48 (d, J = 5.2 Hz, 1H), 7.33 (m, 2H), 7.43 (m, 2H), 7.51 (dd, J = 8.0, 4.0 Hz, 1H), 7.90 (s, 1H), 8.12 (m, 3H), 8.48 (d, J = 5.2 Hz, 1H), 9.14 (dd, J = 4.0, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 466 (M+Na)⁺

Example 85: 2-(4-Bromo-phenyl)-3'-(6,7-dimethoxy-quinolin-4-yloxy)-[1,8]naphthyridine (compound 85)

[0291] 2-(4-Bromo-phenyl)-[1,8]naphthyridin-3-ol (11 mg), 4-chloro-6,7-dimethoxyquinoline (24 mg), and 4-dimethylaminopyridine (13 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 5.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (9 mg, yield 50%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.01 (s, 3H), 4.06 (s, 3H), 6.50 (d, J = 5.2 Hz, 1H), 7.45 (m, 2H), 7.49 (m, 3H), 7.92 (s, 1H), 8.05 (m, 2H), 8.14 (dd, J = 8.0, 4.0 Hz, 1H), 8.49 (d, J = 5.2 Hz, 1H), 9.16 (dd, J = 4.0, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 510 (M+Na)⁺

Example 86: 4-[3-(6,7-Dimethoxy-quinolin-4-yloxy)-[1,8]naphthyridin-2-yl]-benzonitrile (compound 86)

[0292] 2-Aminopyridine-3-carbaldehyde (100 mg) and 4-(2-bromo-acetyl)-benzonitrile (184 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 4-(3-hydroxy-[1,8]naphthyridin-2-yl)-benzonitrile (7 mg, yield 3%).

4-(3-Hydroxy-[1,8]naphthyridin-2-yl)-benzonitrile (7 mg), 4-chloro-6,7-dimethoxyquinoline (19 mg), and 4-dimethylaminopyridine (10 mg) were suspended in 1,2-dichlorobenzene (1.0 ml), and the suspension was stirred at 140°C for 3.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (2 mg, yield 16%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.98 (s, 3H), 4.04 (s, 3H), 6.47 (d, J = 5.6 Hz, 1H), 7.14 (s, 1H), 7.55 (dd, J = 8.0, 4.0 Hz, 1H), 7.61 (m, 3H), 7.98 (s, 1H), 8.16 (m, 3H), 8.42 (d, J = 5.6 Hz, 1H), 9.16 (dd, J = 4.4, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 457 (M+Na)⁺

Example 88: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-pyridin-3-yl-[1,8]naphthyridine (compound 88)

[0293] 2-Pyridin-3-yl-[1,8]naphthyridin-3-ol (17 mg), 4-chloro-6,7-dimethoxyquinoline (51 mg), and 4-dimethylaminopyridine (28 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 4 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (15 mg, yield 48%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.99 (s, 3H), 4.04 (s, 3H), 6.53 (d, J = 5.6 Hz, 1H), 7.34 (dd, J = 8.0, 4.4 Hz, 1H), 7.44 (s, 1H), 7.45 (s, 1H), 7.55 (dd, J = 8.0, 4.4 Hz, 1H), 7.95 (s, 1H), 8.15 (dd, J = 8.0, 1.6 Hz, 1H), 8.49 (m, 2H), 8.60 (dd, J = 5.2, 1.6 Hz, 1H), 9.17 (dd, J = 4.0, 2.0 Hz, 1H), 9.39 (d, J = 1.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 433 (M+Na)⁺

Example 89: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-pyridin-4-yl-[1,8]naphthyridine (compound 89)

[0294] 2-Amino-pyridine-3-carbaldehyde (100 mg) and 2-bromo-1-pyridin-4-yl-ethanone bromide (230 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 2-pyridin-4-yl-[1,8]naphthyridin-3-ol (3 mg, yield 2%).

2-Pyridin-4-yl-[1,8]naphthyridin-3-ol (11 mg), 4-chloro-6,7-dimethoxyquinoline (33 mg), and 4-dimethylaminopyridine (18 mg) were suspended in 1,2-dichlorobenzene (1.0 ml), and the suspension was stirred at 140°C for 6 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (7 mg, yield 35%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.00 (s, 3H), 4.07 (s, 3H), 6.55 (d, J = 5.2 Hz, 1H), 7.47 (s, 1H), 7.53 (s, 1H), 7.58 (dd, J = 8.0, 4.4 Hz, 1H), 7.97 (s, 1H), 8.03 (m, 2H), 8.19 (dd, J = 8.0, 2.0 Hz, 1H), 8.52 (d, J = 5.2 Hz, 1H), 8.66 (m, 2H), 9.21 (dd, J = 8.0, 1.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 433 (M+Na)⁺

Example 90: 2-Benzo[b]thiophen-3-yl-3-(quinolin-4-yloxy)-[1,8]naphthyridine (compound 90)

[0295] 2-Aminopyridine-3-carbaldehyde (100 mg) and 1-benzo[b]thiophen-3-yl-2-chloro-ethanone (173 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 2-benzo[b]thiophen-3-yl-[1,8]naphthyridin-3-ol (88 mg, yield 39%).

2-Benzo[b]thiophen-3-yl-[1,8]naphthyridin-3-ol (15 mg), 4-chloroquinoline (26 mg), and 4-dimethylaminopyridine (20 mg) were suspended in 1,2-dichlorobenzene (1.0 ml), and the suspension was stirred at 120°C for 7 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (13 mg, yield 59%).

¹H-NMR (CDCl₃, 400 MHz): δ 6.59 (d, J = 5.2 Hz, 1H), 7.38 (dd, J = 8.0, 8.0 Hz, 1H), 7.47 - 7.62 (m, 3H), 7.80 (m, 2H), 7.97 (s, 1H), 8.13 (m, 2H), 8.22 (s, 1H), 8.28 (d, J = 8.4 Hz, 1H), 8.62 (d, J = 5.2 Hz, 1H), 8.86 (d, J = 8.4 Hz, 1H), 9.19 (dd, J = 4.4, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 428 (M+Na)⁺

Example 91: 2-Benzo[b]thiophen-3-yl-3-(6,7-dimethoxy-quinolin-4-yloxy)-[1,8]naphthyridine (compound 91)

[0296] 2-Benzo[b]thiophen-3-yl-[1,8]naphthyridin-3-ol (24 mg), 4-chloro-6,7-dimethoxyquinoline (58 mg), and 4-dimethylaminopyridine (32 mg) were suspended in 1,2-dichlorobenzene (1.0 ml), and the suspension was stirred at 140°C for 4 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (29 mg, yield 72%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.92 (s, 3H), 4.02 (s, 3H), 6.54 (d, J = 5.2 Hz, 1H), 7.36 - 7.54 (m, 5H), 7.83 (d, J = 8.4 Hz, 1H), 7.99 (s, 1H), 8.15 (m, 2H), 8.45 (d, J = 5.2 Hz, 1H), 8.80 (d, J = 8.4 Hz, 1H), 9.18 (dd, J = 4.0, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 488 (M+Na)⁺

Example 92: 6,7-Dimethoxy-4-(2-pyrimidin-2-yl-quinolin-3-yloxy)-quinoline (compound 92)

[0297] 2-Aminobenzaldehyde (650 mg) was dissolved in dichloromethane (20 ml). Chloroacetyl chloride (728 mg) was added to the solution, and the mixture was stirred at room temperature overnight. Water was added thereto, and the mixture was extracted with dichloromethane. The dichloromethane layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and

the residue was purified by column chromatography with a chloroform system to give 2-chloro-N-(2-formyl-phenyl)-acetamide (1.05 g, yield 99%).

2-Chloro-N-(2-formyl-phenyl)-acetamide (960 mg) was dissolved in a mixed solvent composed of water (60 ml) and methanol (24 ml) at 100°C. A 10% aqueous potassium hydroxide solution (12 ml) was added dropwise to the solution, and the mixture was heated under reflux for one hr. The reaction mixture was cooled to room temperature, and the methanol was removed under the reduced pressure. The residue was neutralized with a 1 N aqueous hydrochloric acid solution. The resultant precipitate was collected by filtration, was washed with ethyl acetate, and was dried in vacuo to give 2,3-dihydroxyquinoline (450 mg, yield 26%).

2,3-Dihydroxyquinoline (450 mg), 4-chloro-6,7-dimethoxyquinoline (575 mg), and 4-dimethylaminopyridine (472 mg) were suspended in 1,2-dichlorobenzene (12 ml), and the suspension was stirred at 135°C for 5.5 hr. The reaction mixture was cooled to room temperature, water was added thereto, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 3-(6,7-dimethoxy-quinolin-4-yloxy)-quinolin-2-ol (344 mg, yield 77%).

[0298] 3-(6,7-Dimethoxy-quinolin-4-yloxy)-quinolin-2-ol (50 mg), diphosphorus pentoxide (51 mg), and tetrabutylammonium bromide (69 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 140°C for 1.5 hr. The reaction mixture was cooled to room temperature, and a 10% aqueous sodium hydrogencarbonate solution was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 4-(2-bromo-quinolin-3-yloxy)-6,7-dimethoxy-quinoline (5 mg, yield 8%).

4-(2-Bromo-quinolin-3-yloxy)-6,7-dimethoxy-quinoline (50 mg), tetrakis(triphenylphosphine) palladium (0) (28 mg), and copper(II) oxide (19 mg) were suspended in N,N-dimethylformamide (1.5 ml). 2-Tributylstannylpyrimidine (90 mg) was added to the suspension, and the mixture was stirred at 100°C overnight. The reaction mixture was cooled to room temperature and was then filtered. The solvent was removed from the filtrate by distillation under the reduced pressure. Water was added thereto, and the mixture was extracted with dichloromethane. The dichloromethane layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (28 mg, yield 56%).

¹H-NMP, (CDCl₃, 400 MHz): δ 4.05 (s, 6H), 6.44 (d, J = 5.2 Hz, 1H), 7.43 - 7.78 (m, 8H), 7.88 (s, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.52 (d, J = 5.2 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 411 (M⁺+1)

Example 93: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-phenyl-[1,6]naphthyridine (compound 93)

[0299] 4-Aminopyridine-3-carbaldehyde (100 mg) and 2-bromo-1-phenyl-ethanone (127 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give 2-phenyl-[1,6]naphthyridin-3-ol (9 mg, yield 5%). 2-Phenyl-[1,6]naphthyridin-3-ol (17 mg), 4-chloro-6,7-dimethoxyquinoline (51 mg), and 4-dimethylaminopyridine (28 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 7.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (17 mg, yield 54%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.00 (s, 3H), 4.04 (s, 3H), 6.51 (d, J = 5.2 Hz, 1H), 7.38 (m, 3H), 7.44 (m, 2H), 8.02 (m, 4H), 8.47 (d, J = 9.2 Hz, 1H), 8.79 (d, J = 5.2 Hz, 1H), 9.23 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 410 (M+1)⁺

Example 95: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-pyridin-3-yl-[1,6]naphthyridine (compound 95)

[0300] 2-Pyridin-3-yl-[1,6]naphthyridin-3-ol (18 mg), 4-chloro-6,7-dimethoxyquinoline (54 mg), and 4-dimethylaminopyridine (30 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 5.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by

thin layer chromatography with a chloroform-methanol system to give the title compound (7 mg, yield 21%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.01 (s, 3H), 4.05 (s, 3H), 6.53 (d, J = 5.2 Hz, 1H), 7.35 (dd, J = 8.4, 5.2 Hz, 1H), 7.43 (s, 1H), 7.50 (s, 1H), 8.04 (m, 2H), 8.34 (m, 1H), 8.50 (d, J = 5.2 Hz, 1H), 8.63 (dd, J = 4.8, 1.6 Hz, 1H), 8.83 (d, J = 5.2 Hz, 1H), 9.26 (s, 1H), 9.30 (d, J = 1.6 Hz, 1H)

5 Mass spectrometric value (ESI-MS, m/z): 433 (M+Na)⁺

Example 97: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-methyl-[1,7]naphthyridine (compound 97)

10 **[0301]** (4-Formyl-pyridin-3-yl)-carbamic acid tert-butyl ester (100 mg) was dissolved in a hydrochloric acid-methanol solution (2.0 ml), and the solution was stirred under reflux for 30 min. The solvent was removed by distillation under the reduced pressure. 1-Chloro-propan-2-one (42 mg) dissolved in a 5 N aqueous sodium hydroxide solution (0.5 ml) was added to the residue, and the mixture was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give 2-methyl-[1,7]naphthyridin-3-ol (22 mg, yield 31%).

15 2-Methyl-[1,7]naphthyridin-3-ol (22 mg), 4-chloro-6,7-dimethoxyquinoline (92 mg), and 4-dimethylaminopyridine (50 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 8.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (25 mg, yield 53%). ¹H-NMR (CDCl₃, 400 MHz): δ 2.76 (s, 3H), 4.01 (s, 3H), 4.06 (s, 3H), 6.54 (d, J = 5.6 Hz, 1H), 7.44 (s, 1H), 7.49 (s, 1H), 7.52 (d, J = 6.0 Hz, 1H), 7.61 (s, 1H), 8.57 (m, 2H), 9.45 (s, 1H)

25 Mass spectrometric value (ESI-MS, m/z): 348 (M+1)⁺

Example 98: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-2-phenyl-[1,7]naphthyridine (compound 98)

30 **[0302]** (4-Formyl-pyridin-3-yl)-carbamic acid tert-butyl ester (100 mg) was dissolved in a hydrochloric acid-methanol solution (2.0 ml), and the solution was stirred under reflux for 30 min. The solvent was removed by distillation under the reduced pressure. 2-Chloro-1-phenyl-ethanone (70 mg) dissolved in a 5 N aqueous sodium hydroxide solution (0.6 ml) was then added to the residue, and the mixture was allowed to stand in an airtightly stoppered state for two days. The reaction solution was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-acetone system to give 2-phenyl-[1,7]naphthyridin-3-ol (3 mg, yield 3%).

35 2-Phenyl-[1,7]naphthyridin-3-ol (3 mg), 4-chloro-6,7-dimethoxyquinoline (9 mg), and 4-dimethylaminopyridine (5 mg) were suspended in 1,2-dichlorobenzene (1.0 ml), and the suspension was stirred at 140°C for 9 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (3 mg, yield 54%).

40 ¹H-NMR (CDCl₃, 400 MHz): δ 4.00 (s, 3H), 4.07 (s, 3H), 6.59 (d, J = 5.6 Hz, 1H), 7.39 (m, 4H), 7.61 (m, 2H), 7.86 (s, 1H), 7.98 (m, 2H), 8.50 (d, J = 5.6 Hz, 1H), 8.64 (d, J = 5.6 Hz, 1H) 9.62 (s, 1H)

45 Mass spectrometric value (ESI-MS, m/z): 432 (M+Na)⁺

Example 99: 7-Methoxy-4-(2-phenyl-5,6,7,8-tetrahydro-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylate benzylamide (compound 99)

50 **[0303]** 7-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylate benzylamide (compound 65) (164 mg) was dissolved in N,N-dimethylformamide (4 ml). Triethylamine (0.4 ml) and 20% palladium hydroxide (16 mg) were added to the solution, and the mixture was stirred under a hydrogen gas atmosphere at room temperature overnight. The reaction mixture was filtered and was then washed with chloroform. The solvent was removed by distillation under the reduced pressure, water was added to the residue, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (138 mg, yield 84%).

55 ¹H-NMR (CDCl₃, 400 MHz): δ 2.00 (m, 2H), 2.81(t, J = 6.1 Hz, 2H), 3.50 (m, 2H), 4.04 (s, 3H), 4.76 (d, J = 5.6 Hz, 2H),

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6.35 (d, J = 5.1 Hz, 1H), 7.07 (s, 1H), 7.15 - 7.45 (m, 8H), 7.75 - 7.78 (m, 2H), 8.22 (m, 1H), 8.51 (d, J = 5.4 Hz, 1H), 9.29 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 539 (M+Na)⁺

5 Example 100: 1-[2-(1H-[1,8]naphthyridin-4-ylideneamino)-pyridin-3-yl]-ethanone (compound 100)

[0304] 3-Acetyl-2-aminopyridine (25 mg) was dissolved in anhydrous tetrahydrofuran (1 ml). Sodium methoxide (50 mg) was added to the solution, and the mixture was stirred at room temperature. Ethyl formate (68 mg) was added thereto, and the mixture was stirred at room temperature overnight. Anhydrous N,N-dimethylformamide (1 ml) was added to the reaction mixture, and the mixture was stirred at 90 °C for another overnight period. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (4.6 mg, yield 9%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.82 (s, 3H), 7.19 (dd, J = 7.8, 4.6 Hz, 1H), 7.56 (dd, J = 8.3, 4.1 Hz, 1H), 7.80 (s, 1H), 8.22 (dd, J = 7.8, 1.5 Hz, 1H), 8.37 (dd, J = 4.6, 1.4 Hz, 1H), 8.41 (dd, J = 8.5, 2.0 Hz, 1H), 9.16 (dd, J = 4.1, 1.9 Hz, 1H), 9.73 (d, J = 10.0 Hz, 1H), 12.65 - 12.73 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 287 (M+Na)⁺

20 Example 101: (6,7-Dimethoxy-quinazolin-4-yl)-(2-phenyl-[1,8]naphthyridin-3-yl)-amine (compound 101)

[0305] 2-Amino-1-phenyl-ethanone hydrochloride (1.00 g) was dissolved in acetonitrile (15 ml). Di-tert-butyl dicarbonate (1.58 g), triethylamine (1.30 g), and 4-dimethylaminopyridine (71 mg) were added to the solution, and the mixture was stirred at room temperature for one hr. Water and dichloromethane were added to the reaction mixture for extraction.

25 The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give (2-oxo-2-phenyl-ethyl)-carbamic acid tert-butyl ester (950 mg, yield 70%).

2-Aminopyridine-3-carbaldehyde (150 mg) and (2-oxo-2-phenyl-ethyl)-carbamic acid tert-butyl ester (289 mg) were suspended in a 5 N aqueous sodium hydroxide solution (1.0 ml), and the suspension was allowed to stand in an airtightly stoppered state for two days. The reaction mixture was neutralized with 10% hydrochloric acid, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give (2-phenyl-[1,8]naphthyridin-3-yl)-carbamic acid tert-butyl ester (251 mg, yield 64%).

35 **[0306]** (2-Phenyl-[1,8]naphthyridin-3-yl)-carbamic acid tert-butyl ester (247 mg) was dissolved in a hydrochloric acid-methanol solution (10 ml), and the solution was heated under reflux for 45 min. The reaction mixture was neutralized with 10% sodium hydroxide, and dichloromethane was then added thereto for extraction. The dichloromethane layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give 2-phenyl-[1,8]naphthyridin-3-ylamine (155 mg, yield 91%).

40 2-Phenyl-[1,8]naphthyridin-3-ylamine (20 mg) and 4-chloro-6,7-dimethoxyquinazoline (51 mg) were suspended in 2-propanol (3.0 ml). A hydrochloric acid-methanol solution (0.2 ml) was added to the suspension, and the mixture was stirred under reflux overnight. The solvent was removed by distillation under the reduced pressure. A saturated aqueous sodium hydrogencarbonate solution was added to the residue, and the mixture was extracted with chloroform. The chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was then removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give the title compound (4 mg, yield 11%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.78 (s, 3H), 4.01 (s, 3H), 6.55 (brs, 1H), 7.30 (s, 1H), 7.55 (m, 4H), 7.85 (m, 2H), 8.31 (dd, J = 8.4, 2.0 Hz, 1H), 8.75 (s, 1H), 9.03 (dd, J = 4.0, 2.0 Hz, 1H), 9.68 (brs, 1 H),

50 Mass spectrometric value (ESI-MS, m/z): 432 (M+Na)⁺

Example 101: 3-(6,7-Difluoro-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 101)

[0307] 3,4-Difluoroaniline (1.32 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxo,n-4,6-dione (2.0 g) were dissolved in 2-propanol (40 ml), and the solution was stirred at 70 °C for 30 min. The reaction mixture was filtered and was washed with methanol and then with ether. The residue as such was used in the next reaction without purification.

55 The residue and biphenyl (5.8 g) were suspended in diphenyl ether (20 ml), and the suspension was stirred at 220 °C for one hr. The reaction mixture was filtered and was washed with chloroform, and the residue as such was used in the

next reaction without purification.

The residue was suspended in diisopropylethylamine (7 ml), phosphorus oxychloride (2 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 4-chloro-6,7-difluoro-quinoline (0.94 g, yield 46%) (3 steps).

[0308] 2-Phenyl-[1,8]naphthyridin-3-ol (56 mg), 4-chloro-6,7-difluoro-quinoline (50 mg), and 4-dimethylaminopyridine (92 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 6 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (24 mg, yield 25%).

¹H-NMR (CDCl₃, 400 MHz): δ 6.49 (d, J = 5.4 Hz, 1H), 7.32 - 7.36 (m, 3H), 7.58 (dd, J = 4.1, 8.1 Hz, 1H), 7.96 (m, 1H), 8.04 - 8.07 (m, 3H), 8.13 (m, 1H), 8.22 (dd, J = 2.0, 8.3 Hz, 1H), 8.58 (d, J = 5.4 Hz, 1H), 9.22 (dd, J = 2.0, 4.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 408 (M+Na)⁺

Example 102: 2-Phenyl-3-(5,6,7-trifluoro-quinolin-4-yloxy)-[1,8]naphthyridine (compound 102)

[0309] 3,4,5-Trifluoroaniline (1.20 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.93 g) were dissolved in 2-propanol (40 ml), and the solution was stirred at 70°C for 30 min. The reaction mixture was filtered and was washed with methanol and then with ether, and the residue was used in the next reaction without purification.

The residue and biphenyl (6.3 g) were suspended in diphenyl ether (25 ml), and the suspension was stirred at 220°C for one hr. The reaction mixture was filtered and was washed with chloroform, and the residue as such was used in the next reaction without purification.

The residue was suspended in diisopropylethylamine (5 ml), phosphorus oxychloride (1 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 4-chloro-5,6,7-trifluoro-quinoline (176 mg, yield 10%) (3 steps).

[0310] 2-Phenyl-[1,8]naphthyridin-3-ol (51 mg), 4-chloro-5,6,7-trifluoro-quinoline (50 mg), and 4-dimethylaminopyridine (84 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (6 mg, yield 6%).

¹H-NMR (CDCl₃, 400 MHz): δ 6.45 (d, J = 5.1 Hz, 1H), 7.34 - 7.39 (m, 3H), 7.57 (dd, J = 4.1, 8.1 Hz, 1H), 7.72 (m, 1H), 8.00 (s, 1H), 8.13 - 8.15 (m, 2H), 8.21 (dd, J = 2.0, 8.1 Hz, 1H), 8.53 (d, J = 5.1 Hz, 1H), 9.20 (dd, J = 2.0, 4.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 426 (M+Na)⁺

Example 103: 3-(6-Fluoro-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 103)

[0311] 4-Chloro-6-fluoro-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (55 mg), and 4-dimethylaminopyridine (101 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (269 mg) was added to the suspension, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (87 mg, yield 90%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.51 (d, J = 3.7 Hz, 1H), 7.10 (ddd, J = 1.0, 4.9, 7.6 Hz, 1H), 7.38 (s, 1H), 7.54 - 7.64 (m, 2H), 7.90 (d, J = 7.6 Hz, 1H), 7.98 (dd, J = 2.7, 9.0 Hz, 1H), 8.21 (m, 1H), 8.36 (m, 1H), 8.54 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 368 (M+Na)⁺

Example 104: 3-(7-Fluoro-6-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 104)

[0312] 4-Chloro-7-fluoro-6-methoxy-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (47 mg), and 4-dimethylaminopyridine (87 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (231 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (47 mg, yield 52%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 4.04 (s, 3H), 6.47 (d, J = 5.6 Hz, 1H), 7.11 (ddd, J = 1.0, 4.9, 7.6 Hz, 1H), 7.39 (s, 1H), 7.63 (m, 1H), 7.70 (d, J = 9.0 Hz, 1H), 7.88 - 7.90 (m, 2H), 8.35 (m, 1H), 8.45 (d, J = 5.6 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 398 (M+Na)⁺

Example 105: 3-(7-Chloro-6-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 105)

[0313] 4,7-Dichloro-6-methoxy-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (44 mg), and 4-dimethylaminopyridine (80 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (214 mg) was added to the solution, and the mixture was stirred at 130°C for overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (80 mg, yield 93%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 4.05 (s, 3H), 6.47 (d, J = 5.4 Hz, 1H), 7.11 (ddd, J = 1.2, 5.1, 7.6 Hz, 1H), 7.39 (s, 1H), 7.63 (m, 1H), 7.66 (s, 1H), 7.88 (d, J = 7.8 Hz, 1H), 8.22 (m, 1H), 8.36 (m, 1H), 8.44 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 414 (M+Na)⁺

Example 106: 3-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-7-yl]-phenol (compound 106)

[0314] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-Bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and 3-hydroxyphenylboric acid (31 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (DMSO-d₆, 400 MHz): δ 2.35 (s, 3H), 2.54 (s, 3H), 6.49 (d, J = 5.1 Hz, 1H), 6.83 (ddd, J = 8.0, 2.4, 1.0 Hz, 1H), 7.16 - 7.27 (m, 3H), 7.33 (dd, J = 7.8, 7.8 Hz, 1H), 7.66 (s, 1H), 7.76 (ddd, J = 7.8, 7.8, 2.0 Hz, 1H), 7.83 - 7.89 (m, 2H), 8.11 (d, J = 1.7 Hz, 1H), 8.20 - 8.23 (m, 2H), 8.31 (d, J = 1.8 Hz, 1H), 8.57 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 418 (M-1)⁻

Example 107: 4-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-7-yl]-phenol (compound 107)

[0315] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and 4-hydroxyphenylboric acid (31 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (31 mg, yield 100%).

¹H-NMR (DMSO-d₆, 400 MHz): δ 2.35 (s, 3H), 2.54 (s, 3H), 6.45 (d, J = 5.1 Hz, 1H), 6.90 (d, J = 8.6 Hz, 2H), 7.19 (ddd, J = 7.3, 4.9, 1.2 Hz, 1H), 7.64 - 7.70 (m, 3H), 7.75 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.83 - 7.90 (m, 2H), 8.08 (d, J = 1.7 Hz, 1H), 8.20 - 8.24 (m, 1H), 8.27 (d, J = 8.8 Hz, 1H), 8.54 (d, J = 5.2 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 418 (M-1)⁻

Example 108: 2-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-7-yl]-phenylamine (compound 108)

[0316] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and 2-aminophenylboric acid (30 mg) under an argon atmosphere and the mixture was stirred at 70 °C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with chloroform-methanol to give the title compound (31 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 3.86 (bs, 2H), 6.46 (d, J = 5.1 Hz, 1H), 6.81 (d, J = 8.0 Hz, 1H), 6.88 (dd, J = 7.6, 7.6 Hz, 1H), 7.09 - 7.15 (m, 1H), 7.17 - 7.28 (m, 2H), 7.38 (s, 1H), 7.60 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.69 (dd, J = 8.5, 1.4 Hz, 1H), 7.85 (d, J = 8.0 Hz, 1H), 8.14 (s, 1H), 8.41 (d, J = 8.6 Hz, 1H), 8.53 (d, J = 4.6 Hz, 1H), 8.60 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 419 (M+1)⁺

Example 110: 3-(6-Fluoro-7-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 110)

[0317] 4-Chloro-6-fluoro-7-methoxy-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (47 mg), and 4-dimethylaminopyridine (87 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (231 mg) was added to the solution, and the mixture was stirred at 130 °C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (50 mg, yield 55%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.66 (s, 3H), 4.07 (s, 3H), 6.43 (d, J = 5.6 Hz, 1H), 7.10 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.38 (s, 1H), 7.60 - 7.68 (m, 2H), 7.90 (d, J = 8.1 Hz, 1H), 7.97 (d, J = 11.2 Hz, 1H), 8.34 (m, 1H), 8.46 (d, J = 5.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 398 (M+Na)⁺

Example 111: 3-(6,8-Difluoro-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 111)

[0318] 4-Chloro-6,8-difluoro-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (50 mg), and 4-dimethylaminopyridine (92 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (245 mg) was added to the solution, and the mixture was then stirred at 130 °C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (18 mg, yield 20%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.68 (s, 3H), 6.54 (d, J = 5.4 Hz, 1H), 7.17 (m, 1H), 7.28 (m, 1H), 7.37 (s, 1H), 7.68 (m, 1H), 7.79 (ddd, J = 1.5, 4.1, 9.0 Hz, 1H), 7.91 (d, J = 7.8 Hz, 1H), 8.48 (m, 1H), 8.59 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 386 (M+Na)⁺

Example 113: Methyl 4-(2-Phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-7-carboxylate (compound 113)

[0319] 3-Amino-2,5-dichlorobenzoic acid (1.74 g), 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (3.70 g), and 1-hydroxybenzotriazole hydrate (2.66 g) were dissolved in N,N-dimethylformamide (40 ml). Methanol (5 ml) was added to the solution, and the mixture was stirred at room temperature for 5 hr. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give methyl 3-amino-2,5-dichlorobenzoate (1.45 g, yield 78%).

Methyl 3-amino-2,5-dichlorobenzoate (1.45 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.50 g) were suspended in 2-propanol (40 ml), and the suspension was stirred at 70 °C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was then collected by filtration and was washed with methanol and then with ether. The crystal thus obtained as such was used in the next reaction without further purification.

The crystal prepared above and biphenyl (5.8 g) were suspended in diphenyl ether (25 ml), and the suspension was

stirred at 220°C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with chloroform. The crystal thus obtained (1.19 g) as such was used in the next reaction without further purification.

[0320] A part of the residue (0.59 g) was dissolved in N,N-dimethylformamide (20 ml). Triethylamine (4 ml) and 10% palladium/carbon (0.59 g) were added to the solution, and the mixture was stirred under a hydrogen gas atmosphere at room temperature overnight. The reaction mixture was filtered and was then washed with chloroform. The solvent was removed by distillation under the reduced pressure, and the residue was washed with methanol to give methyl 4-oxo-1,4-dihydro-quinoline-7-carboxylate (187 mg, yield 28%) (3 steps).

Methyl 4-oxo-1,4-dihydro-quinoline-7-carboxylate (650 mg) was suspended in diisopropylethylamine (7 ml), phosphorus oxychloride (1.5 ml) was added to the suspension, and the mixture was stirred at 120°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give methyl 4-chloro-quinoline-7-carboxylate (609 mg, yield 86%).

[0321] 2-Phenyl-[1,8]naphthyridin-3-ol (100 mg), methyl 4-chloro-quinoline-7-carboxylate (100 mg), and 4-dimethylaminopyridine (165 mg) were suspended in 1,2-dichlorobenzene (3 ml), and the suspension was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (143 mg, yield 78%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.03 (s, 3H), 6.56 (d, J = 5.1 Hz, 1H), 7.29 - 7.35 (m, 3H), 7.57 (dd, J = 4.4, 8.3 Hz, 1H), 8.04 (s, 1H), 8.10 (m, 1H), 8.21 (m, 2H), 8.25 (dd, J = 1.7, 8.8 Hz, 1H), 8.46 (d, J = 8.8 Hz, 1H), 8.69 (d, J = 5.4 Hz, 1H), 8.85 (s, 1H), 9.21 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 430 (M+Na)⁺

Example 115: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-6-fluoro-[2,2']bipyridine (compound 115)

[0322] 2-Fluoro-5-hydroxypyridine (2.00 g) and iodine (44.9 g) were dissolved in a mixed solvent composed of methanol (40 ml) and water (20 ml), and the mixture was stirred at room temperature for 167 hr. Sodium sulfite was added to the reaction mixture until the solution became transparent. Methanol was then removed from the reaction mixture under the reduced pressure. Water was added to the residue, and the mixture was extracted with chloroform. The chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 6-fluoro-2-iodo-pyridin-3-ol (761 mg, yield 18%).

6-Fluoro-2-iodo-pyridin-3-ol (135 mg), 4-chloro-6,7-dimethoxyquinoline (378 mg), and 4-dimethylaminopyridine (207 mg) were suspended in 1,2-dichlorobenzene (8 ml), and the suspension was stirred at 130°C for 3.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-hexane system to give 4-(6-fluoro-2-iodo-pyridin-3-yloxy)-6,7-dimethoxy-quinoline (89 mg, yield 37%).

[0323] 4-(6-Fluoro-2-iodo-pyridin-3-yloxy)-6,7-dimethoxy-quinoline (89 mg), tetrakis(triphenylphosphine) palladium (48 mg), and copper(II) oxide (33 mg) were suspended in N,N-dimethylformamide (2 ml). 2-Tributylstannylpyridine (154 mg) was added to the suspension, and the mixture was stirred at 100°C overnight. The reaction mixture was cooled to room temperature, and the reaction mixture was filtered. The solvent was removed from the filtrate by distillation under the reduced pressure. Water was then added thereto, and the mixture was extracted with dichloromethane. The dichloromethane layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (31 mg, yield 39%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.03 (s, 3H), 4.04 (s, 3H), 6.36 (d, J = 5.2 Hz, 1H), 7.10 (dd, J = 8.8, 4.0 Hz, 1H), 7.26 (ddd, J = 7.6, 4.4, 0.8 Hz, 1H), 7.39 (s, 1H), 7.56 (s, 1H), 7.66 (ddd, J = 9.2, 7.2, 1.6 Hz, 1H), 7.74 (dd, J = 8.4, 6.4 Hz, 1H), 7.90 (d, J = 5.2 Hz, 1H), 8.34 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 400 (M+Na)⁺

Example 116: Methyl 6-methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-7-carboxylate (compound 116)

[0324] Methyl 2-methoxy-5-nitro-benzoate (300 mg), ammonium chloride (228 mg), and zinc (929 mg) were suspended in ethanol (10 ml) and water (0.5 ml), and the suspension was stirred under reflux for 3 hr. The reaction mixture was filtered, and the solvent was removed from the filtrate by distillation under the reduced pressure. A saturated aqueous sodium hydrogencarbonate solution was added to the residue, and the mixture was extracted with chloroform. The chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give methyl 5-amino-2-methoxy-benzoate (244 mg, yield 95%).

Methyl 5-amino-2-methoxy-benzoate (244 mg) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (228 mg) were dissolved in 2-propanol (3 ml), and the solution was stirred at 100°C for 15 hr. The solvent was removed by distillation under the reduced pressure, and the residue was washed with diethyl ether to give methyl 5-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidene)methyl]-amino]-2-methoxy-benzoate (248 mg, yield 55%).

[0325] Methyl 5-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidene)methyl]-amino]-2-methoxy-benzoate (245 mg) and biphenyl (676 mg) were suspended in diphenyl ether (2 ml), and the suspension was stirred at 260°C for 45 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with diethyl ether. The crystal thus obtained as such was used in the next reaction without further purification.

The crystal (45 mg) was suspended in thionyl chloride (1 ml), a minor amount of N,N-dimethylformamide was added to the suspension, and the mixture was stirred at 100°C for 3.5 hr. The reaction mixture was added to a saturated aqueous sodium hydrogencarbonate solution under ice cooling. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give methyl 4-chloro-6-methoxy-quinoline-7-carboxylate (4 mg, yield 2%) (2 steps).

[0326] 2-Phenyl-[1,8]naphthyridin-3-ol (11 mg), methyl 4-chloro-6-methoxy-quinoline-7-carboxylate (4 mg), and 4-dimethylaminopyridine (6 mg) were suspended in 1,2-dichlorobenzene (1 ml), and the suspension was stirred at 120°C for 36 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (5 mg, yield 71%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.98 (s, 3H), 4.02 (s, 3H), 6.57 (d, J = 4.8 Hz, 1H), 7.35 (m, 3H), 7.55 (dd, J = 8.8, 4.4 Hz, 1H), 7.61 (s, 1H), 7.99 (s, 1H), 8.11 (m, 2H), 8.19 (dd, J = 8.0, 1.6 Hz, 1H), 8.44 (s, 1H), 8.56 (d, J = 4.8 Hz, 1H), 9.19 (dd, J = 4.4, 1.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 460 (M+Na)⁺

Example 117: 4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (compound 117)

[0327] A 2.0 M lithium diisopropylamide/heptane, tetrahydrofuran, an ethylbenzene solution (26.2 ml), and tri-n-butyltin hydride (14.1 ml) were added in that order to anhydrous tetrahydrofuran (100 ml) under an argon atmosphere at 0°C, and the mixture was stirred at 0°C for 15 min. The reaction mixture was cooled to -78°C. 2-Chloropyrimidine (5.0 g) dissolved in anhydrous tetrahydrofuran (20 ml) was added dropwise thereto. The mixture was slowly brought to room temperature and was stirred overnight. Water was added to the reaction mixture to stop the reaction. The mixture was filtered through Celite, and the filtrate was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give 2-tri-n-butylstannylpyrimidine (9.1 g, yield 56%).

2-Tri-n-butylstannylpyrimidine (5.0 g) was dissolved in anhydrous tetrahydrofuran (130 ml) under an argon atmosphere. A 1.6 M n-butyllithium/hexane solution (8.6 ml) was added dropwise at -78°C, and the mixture was stirred at -78°C for 30 min. 5-Ethylfurfural (1.85 g) dissolved in anhydrous tetrahydrofuran (20 ml) was added dropwise thereto, and the mixture was brought to room temperature with stirring. Water was added to the reaction mixture to stop the reaction. The solvent was removed by distillation under the reduced pressure, and water was added to the residue. The mixture was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give (5-ethylfuran-2-yl)-pyrimidin-2-yl-methanol (888 mg, yield 32%).

[0328] (5-Ethylfuran-2-yl)-pyrimidin-2-yl-methanol (880 mg) was dissolved in chloroform (15 ml), manganese dioxide (3.8 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered through Celite, and the solvent was removed from the filtrate by distillation under the reduced pressure. The residue was used in the next reaction without purification.

The residue, methanol (7 ml), and a 28% aqueous ammonia solution (8 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-acetone system to give 6-ethyl-2-pyrimidin-2-yl-pyridin-3-ol (305 mg, yield 35%).

Dimethylsulfoxide (2 ml) was added to 6-ethyl-2-pyrimidin-2-yl-pyridin-3-ol (40 mg), 4-chloroquinoline (164 mg), cesium carbonate (196 mg), and 4-dimethylaminopyridine (73 mg), and the mixture was stirred at 130°C for 6 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (47 mg, yield 72%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.41 (t, J = 7.6 Hz, 3H), 3.05 (q, J = 7.6 Hz, 2H), 6.53 (d, J = 5.2 Hz, 1H), 7.10 (t, J = 4.9 Hz, 1H), 7.43 (d, J = 8.3 Hz, 1H), 7.53 (dd, J = 7.1, 7.1 Hz, 1H), 7.61 (d, J = 8.3 Hz, 1H), 7.73 (ddd, J = 8.6, 8.6, 1.2 Hz, 1H), 8.05 (d, J = 8.5 Hz, 1H), 8.31 (d, J = 8.3 Hz, 1H), 8.60 (d, J = 5.1 Hz, 1H), 8.64 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 329 (M+1)⁺

Example 118: 3-(6-Isopropoxy-7-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 118)

[0329] 2-Methoxy-4-nitrophenol (2.46 g) was dissolved in N,N-dimethylformamide (40 ml). Potassium carbonate (3.84 g) and 2-bromopropane (2.0 ml) were added to the solution, and the mixture was stirred at 100°C for 3 hr. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without purification.

The residue was dissolved in N,N-dimethylformamide (40 ml). Triethylamine (5 ml) and 20% palladium hydroxide/carbon (1.48 g) were added to the solution under a hydrogen gas atmosphere, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered and was then washed with chloroform. The solvent was removed by distillation under the reduced pressure, and ethyl acetate was added to the residue. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without purification.

[0330] The residue and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.08 g) were dissolved in 2-propanol (40 ml), and the solution was stirred at 70°C for 30 min. The reaction mixture was cooled to room temperature. The solvent was then removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without purification.

The residue and biphenyl (6.0 g) was suspended in diphenyl ether (25 ml), and the suspension was stirred at 220°C overnight. The reaction mixture was cooled to room temperature, and the reaction mixture as such was purified by column chromatography with a methanol-chloroform system to give 6-isopropoxy-7-methoxy-1H-quinolin-4-one (2.10 g, yield 62%) (4 steps).

6-Isopropoxy-7-methoxy-1H-quinolin-4-one (2.10 g) was suspended in diisopropylethylamine (5 ml), phosphorus oxychloride (1.5 ml) was added to the suspension, and the mixture was stirred at 100°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 4-chloro-6-isopropoxy-7-methoxy-quinoline (2.05 g, yield 90%).

[0331] 2-Phenyl-[1,8]naphthyridin-3-ol (44 mg), 4-chloro-6-isopropoxy-7-methoxy-quinoline (50 mg), and 4-dimethylaminopyridine (73 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 8 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (86 mg, yield 98%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.48 (d, J = 6.1 Hz, 6H), 4.06 (s, 3H), 4.77 (m, 1H), 6.51 (d, J = 5.6 Hz, 1H), 7.34 - 7.36 (m, 3H), 7.53 (s, 1H), 7.56 (dd, J = 4.4, 8.3 Hz, 1H), 7.62 (s, 1H), 8.00 (s, 1H), 8.09 - 8.11 (m, 2H), 8.19 (dd, J = 1.7, 8.1 Hz, 1H), 8.43 (d, J = 5.6 Hz, 1H), 9.19 (dd, J = 1.7, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 460 (M+Na)⁺

Example 119: 3-(6-Methoxy-7-methyl-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 119)

[0332] 4-Chloro-6-methoxy-7-methyl-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (48 mg), and 4-dimethyl-

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aminopyridine (88 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (235 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (45 mg, yield 51%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.45 (s, 3H), 2.67 (s, 3H), 3.99 (s, 3H), 6.47 (d, J = 5.1 Hz, 1H), 7.10 (ddd, J = 1.0, 4.9, 7.3 Hz, 1H), 7.38 (s, 1H), 7.52 (s, 1H), 7.62 (m, 1H), 7.89 (d, J = 8.1 Hz, 1H), 8.02 (m, 1H), 8.36 (m, 1H), 8.40 (d, J = 5.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 394 (M+Na)⁺

Example 120: 3-(6-Isopropoxy-7-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 120)

[0333] 4-Chloro-6-isopropoxy-7-methoxy-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (40 mg), and 4-dimethylaminopyridine (73 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (194 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (45 mg, yield 55%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.46 (d, J = 6.1 Hz, 6H), 2.40 (s, 3H), 2.66 (s, 3H), 4.04 (s, 3H), 4.78 (m, 1H), 6.41 (d, J = 5.6 Hz, 1H), 7.10 (dd, J = 4.9, 7.3 Hz, 1H), 7.38 (s, 1H), 7.56 - 7.62 (m, 3H), 7.86 (d, J = 7.8 Hz, 1H), 8.36 (d, J = 5.9 Hz, 1H), 8.39 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 438 (M+Na)⁺

Example 121: 8-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-2-methoxy-[1,5]naphthyridine (compound 121)

[0334] 5-Amino-2-methoxy-pyridine (1.26 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.06 g) were suspended in 2-propanol (40 ml), and the suspension was stirred at 70°C for 30 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was then collected by filtration and was washed with methanol and then with ether. The crystal thus obtained as such was used in the next reaction without further purification.

The crystal prepared above and biphenyl (5.1 g) were suspended in diphenyl ether (20 ml), and the suspension was stirred at 220°C for one hr. The reaction mixture was cooled to room temperature, and the reaction mixture was then filtered and was washed with chloroform. The residue as such was used in the next reaction without further purification.

[0335] The residue was suspended in diisopropylethylamine (7 ml), phosphorus oxychloride (1.5 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 8-chloro-2-methoxy-[1,5]naphthyridine (572 mg, yield 29%) (3 steps).

8-Chloro-2-methoxy-[1,5]naphthyridine (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (51 mg), and 4-dimethylaminopyridine (94 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (251 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (70 mg, yield 75%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.34 (s, 3H), 2.66 (s, 3H), 3.92 (s, 3H), 6.92 (d, J = 5.4 Hz, 1H), 7.17 - 7.26 (m, 3H), 7.65 (dd, J = 7.6, 7.6 Hz, 1H), 8.16 (d, J = 8.1 Hz, 1H), 8.36 (s, 1H), 8.53 (d, J = 5.9 Hz, 1H), 8.58 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 381 (M+Na)⁺

Example 123: 3-(6-Benzoyloxy-7-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 123),

[0336] 2-Methoxy-4-nitrophenol (2.07 g) was dissolved in N,N-dimethylformamide (40 ml). Potassium carbonate (5.9 g) and benzyl chloride (1.8 ml) were added to the solution, and the mixture was stirred at room temperature overnight. Benzyl chloride (1 ml) was further added to the reaction mixture, and the mixture was stirred at room temperature for 4 days. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate

layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 1-benzyloxy-2-methoxy-4-nitro-benzene (2.94 g, yield 93%).

1-Benzyloxy-2-methoxy-4-nitro-benzene was suspended in ethanol/water (70 ml/7 ml). Ammonium chloride (2.49 g) and zinc (15.3 g) were added to the suspension, and the mixture was stirred at 120°C for 4 hr. The reaction mixture was filtered and was washed with chloroform. The solvent was removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without purification.

[0337] The residue and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.42 g) were suspended in 2-propanol (50 ml), and the suspension was stirred at 70°C for 30 min. The reaction mixture was filtered, and the residue was used in the next reaction without purification.

The residue and biphenyl (6.0 g) were suspended in diphenyl ether (25 ml), and the suspension was stirred at 220°C for one hr. The reaction mixture as such was purified by column chromatography with a methanol-chloroform system to give 6-benzyloxy-7-methoxy-1H-quinolin-4-one (1.0 g, yield 32%) (3 steps).

6-Benzyloxy-7-methoxy-1H-quinolin-4-one (1.0 g) was suspended in diisopropylethylamine (15 ml), phosphorus oxychloride (1.5 ml) was added to the suspension, and the mixture was stirred at 120°C for one hr. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 6-benzyloxy-4-chloro-7-methoxyquinoline (971 mg, yield 90%).

[0338] 2-Phenyl-[1,8]naphthyridin-3-ol (231 mg), 6-benzyloxy-4-chloro-7-methoxyquinoline (306 mg), and 4-dimethylaminopyridine (369 mg) were suspended in 1,2-dichlorobenzene (10 ml), and the suspension was stirred at 130°C for 7 hr and was further stirred at 110°C overnight. Further, 6-benzyloxy-4-chloro-7-methoxyquinoline (30 mg) was added to the reaction mixture, and the mixture was stirred at 130°C for 6 hr and further at 110°C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give the title compound (393 mg, yield 78%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.06 (s, 3H), 5.27 (s, 2H), 6.50 (d, J = 5.1 Hz, 1H), 7.20 (m, 1H), 7.27 - 7.48 (m, 9H), 7.50 (dd, J = 4.1, 8.0 Hz, 1H), 7.76 (d, J = 1.0 Hz, 1H), 8.08 - 8.12 (m, 3H), 8.48 (d, J = 5.1 Hz, 1H), 9.15 (dd, J = 2.0, 4.2 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 508 (M+Na)⁺

Example 124: 7-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinolin-6-ol (compound 124)

[0339] 3-(6-Benzyloxy-7-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 123) (380 mg) was dissolved in trifluoroacetic acid (3 ml). Methanesulfonic acid (0.3 ml) was added to the solution, and the mixture was stirred at room temperature for 3 hr. Water was added to the reaction mixture. The mixture was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-chloroform system to give the title compound (275 mg, yield 89%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.08 (s, 3H), 6.48 (d, J = 5.4 Hz, 1H), 7.27 - 7.34 (m, 3H), 7.44 (s, 1H), 7.50 (dd, J = 4.2, 8.0 Hz, 1H), 7.69 (s, 1H), 7.81 (s, 1H), 8.10 - 8.14 (m, 3H), 8.46 (d, J = 5.1 Hz, 1H), 9.14 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 418 (M+Na)⁺

Example 125: 2-[7-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinolin-6-yloxy]-ethanol compound 125)

[0340] 7-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinolin-6-ol (compound 124) (70 mg) was dissolved in N,N-dimethylformamide (3 ml). Potassium carbonate (180 mg) and 2-bromoethanol (0.1 ml) were added to the solution, and the mixture was stirred at 70°C overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-chloroform system to give the title compound (34 mg, yield 44%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.02 (s, 3H), 4.07 (t, J = 4.1 Hz, 2H), 4.24 (t, J = 4.4 Hz, 2H), 6.49 (d, J = 5.1 Hz, 1H), 7.34 - 7.37 (m, 3H), 7.43 (s, 1H), 7.51 - 7.54 (m, 2H), 7.92 (s, 1H), 8.13 - 8.16 (m, 3H), 8.49 (d, J = 5.4 Hz, 1H), 9.16 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 462 (M+Na)⁺

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Example 126: 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinoline-7-carboxylic acid amide (compound 126)

[0341] Methyl 4-chloro-quinoline-7-carboxylate (100 mg) was dissolved in methanol (5 ml), 28% aqueous ammonia (5 ml) was added to the solution, and the mixture was stirred at 40°C overnight. The solvent was removed by distillation under the reduced pressure. Water was added to the residue, and the mixture was extracted with chloroform. The organic layer was then washed with saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue (58.5 mg) as such was used in the next reaction without purification.

A part of the residue (55 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (53 mg), and 4-dimethylaminopyridine (98 mg) was dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (260 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (5 mg, yield 3%) (2 steps).

¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 2.67 (s, 3H), 6.59 (d, J = 5.4 Hz, 1H), 7.08 (m, 1H), 7.41 (s, 1H), 7.61 (m, 1H), 7.92 (d, J = 8.1 Hz, 1H), 8.13 (d, J = 8.8 Hz, 1H), 8.28 (d, J = 4.1 Hz, 1H), 8.53 (d, J = 8.8 Hz, 1H), 8.64 - 8.68 (m, 2H)
Mass spectrometric value (ESI-MS, m/z): 393 (M+Na)⁺

Example 128: 2-Methoxy-8-(2-phenyl-[1,8]naphthyridin-3-yloxy)-[1,5]naphthyridine (compound 128)

[0342] 2-Phenyl-[1,8]naphthyridin-3-ol (57 mg), 8-chloro-2-methoxy-[1,5]naphthyridine (50 mg), and 4-dimethylaminopyridine (94 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 8 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (27 mg, yield 28%).

¹H-NMR (CDCl₃, 400 MHz): δ 3.68 (s, 3H), 7.15 (d, J = 9.0 Hz, 1H), 7.18 (d, J = 5.1 Hz, 1H), 7.40 - 7.42 (m, 3H), 7.46 (dd, J = 4.4, 8.3 Hz, 1H), 7.58 (s, 1H), 8.03 (dd, J = 2.0, 8.3 Hz, 1H), 8.32 (d, J = 9.3 Hz, 1H), 8.38 - 8.41 (m, 2H), 8.69 (d, J = 5.1 Hz, 1H), 9.10 (dd, J = 2.0, 4.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 403 (M+Na)⁺

Example 130: 3-(5,6-Dichloro-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 130)

[0343] 4,5,6-Trichloroquinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (43 mg), and 4-dimethylaminopyridine (79 mg) were dissolved in dimethylsulfoxide (1.5 ml). Cesium carbonate (210 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (57 mg, yield 66%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.68 (s, 3H), 6.67 (d, J = 5.4 Hz, 1H), 7.17 (m, 1H), 7.32 (s, 1H), 7.68 (dd, J = 7.3, 7.6 Hz, 1H), 7.81 (d, J = 9.0 Hz, 1H), 8.03 (d, J = 7.8 Hz, 1H), 8.07 (m, 1H), 8.47 (m, 1H), 8.56 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 418 (M+Na)⁺

Example 131: 3-(6,7-Dichloro-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 131)

[0344] 4,6,7-Trichloroquinoline (62 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (54 mg), and 4-dimethylaminopyridine (98 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (262 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (70 mg, yield 65%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.48 (d, J = 5.4 Hz, 1H), 7.12 (m, 1H), 7.38 (s, 1H), 7.65 (m, 1H), 7.92 (d, J = 7.8 Hz, 1H), 8.27 - 8.35 (m, 2H), 8.50 (d, J = 2.2 Hz, 1H), 8.55 (dd, J = 1.7, 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 418 (M+Na)⁺

Example 132: 3-(6-Bromo-7-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (compound 132)

[0345] 1-Bromo-2-methoxy-4-nitrobenzene (2.32 g) was suspended in ethanol/water (60 ml/5 ml). Ammonium chloride (1.94 g) and zinc (10.1 g) were added to the suspension, and the mixture was stirred at 120°C for 3 hr. The reaction mixture was filtered and was washed with methanol. The solvent was removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without purification.

The residue and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (2.3 g) were dissolved in 2-propanol (60 ml), and the solution was stirred at 70°C for one hr. The reaction mixture was filtered and was washed with methanol, and the residue as such was used in the next reaction without purification.

The residue and biphenyl (6.86 g) were suspended in diphenyl ether (25 ml), and the suspension was stirred at 220°C for 3 hr. The reaction mixture was cooled to room temperature, was filtered and was washed with chloroform, and the residue as such was used in the next reaction without purification.

[0346] The residue was suspended in diisopropylethylamine (7 ml), phosphorus oxychloride (2 ml) was added to the suspension, and the mixture was stirred at 100°C for one hr. Water was added to the reaction mixture under ice cooling.

The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give 6-bromo-4-chloro-7-methoxy-quinoline (1.25 g, yield 46%) (4 steps).

2-Phenyl-[1,8]naphthyridin-3-ol (163 mg), 6-bromo-4-chloro-7-methoxy-quinoline (200 mg), and 4-dimethylaminopyridine (269 mg) were suspended in 1,2-dichlorobenzene (3 ml), and the suspension was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (145 mg, yield 43%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.09 (s, 3H), 6.40 (d, J = 5.6 Hz, 1H), 7.33 - 7.37 (m, 3H), 7.57 (dd, J = 4.1, 8.1 Hz, 1H), 7.61 (s, 1H), 8.03 (s, 1H), 8.06 - 8.08 (m, 2H), 8.22 (dd, J = 2.0, 8.3 Hz, 1H), 8.52 (d, J = 5.6 Hz, 1H), 8.62 (s, 1H), 9.21 (dd, J = 2.0, 4.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 480 (M+Na)⁺

Example 133: 3-(6-Bromo-7-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 133)

[0347] 6-Bromo-4-chloro-7-methoxy-quinoline (200 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (147 mg), and 4-dimethylaminopyridine (269 mg) were dissolved in dimethylsulfoxide (3 ml), cesium carbonate (717 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (308 mg, yield 97%). ¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.66 (s, 3H), 4.07 (s, 3H), 6.39 (d, J = 5.6 Hz, 1H), 7.11 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.37 (s, 1H), 7.52 (s, 1H), 7.63 (m, 1H), 7.91 (d, J = 8.1 Hz, 1H), 8.35 (s, 1H), 8.48 (d, J = 5.6 Hz, 1H), 8.48 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 458 (M+Na)⁺

Example 136: 3-(6-Benzyloxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 136)

[0348] 4-Benzyloxy-aniline hydrochloride (1.18 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.03 g) were suspended in 2-propanol (15 ml). Triethylamine (0.78 ml) was added to the suspension, and the mixture was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, was filtered, and was washed with diethyl ether. The residue as such was used in the next reaction without purification.

The residue and biphenyl (4.34 g) were suspended in diphenyl ether (12 ml), and the suspension was stirred at 240°C overnight. The reaction mixture was cooled to room temperature, and the cooled reaction mixture as such was applied to column chromatography with a methanol-chloroform system. The crude product as such was used in the next reaction without further purification.

The crude product was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (0.5 ml) was added to the suspension, and the mixture was stirred at 120°C for 3 hr. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium

sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 6-benzyloxy-4-chloro-quinoline (147 mg, yield 10%) (3 steps).

[0349] 6-Benzyloxy-4-chloro-quinoline (147 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (140 mg), and 4-dimethylaminopyridine (200 mg) were dissolved in dimethylsulfoxide (3 ml), cesium carbonate (540 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give the title compound (158 mg, yield 66%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.66 (s, 3H), 5.21 (s, 2H), 6.43 (d, J = 5.1 Hz, 1H), 7.10 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.35 - 7.55 (m, 8H), 7.67 (d, J = 2.7 Hz, 1H), 7.76 (m, 1H), 7.96 (d, J = 9.3 Hz, 1H), 8.44 (d, J = 5.1 Hz, 1H), 8.51 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 456 (M+Na)⁺

Example 137: 3-(7-Benzyloxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 137)

[0350] 3-Benzyloxy-aniline (1.0 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.03 g) were suspended in 2-propanol (15 ml) and the suspension was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, was filtered, and was washed with ether. The residue as such was used in the next reaction without purification.

The residue and biphenyl (4.34 g) were suspended in diphenyl ether (12 ml), and the suspension was stirred at 240°C overnight. The reaction mixture was cooled to room temperature, and the cooled reaction mixture as such was applied to column chromatography with a methanol-chloroform system. The crude product as such was used in the next reaction without further purification.

The crude product was suspended in diisopropylethylamine (7 ml), phosphorus oxychloride (1.5 ml) was added to the suspension, and the mixture was stirred at 120°C for 30 min. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 7-benzyloxy-4-chloro-quinoline (222 mg, yield 16%) (3 steps).

[0351] 7-Benzyloxy-4-chloro-quinoline (222 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (220 mg), and 4-dimethylaminopyridine (302 mg) were dissolved in dimethylsulfoxide (3 ml), cesium carbonate (820 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give the title compound (239 mg, yield 67%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.38 (s, 3H), 2.66 (s, 3H), 5.21 (s, 2H), 6.32 (d, J = 5.1 Hz, 1H), 7.10 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.26 - 7.59 (m, 9H), 7.80 (d, J = 7.9 Hz, 1H), 8.23 (d, J = 9.0 Hz, 1H), 8.48 (d, J = 5.1 Hz, 1H), 8.52 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 456 (M+Na)⁺

Example 138: 3-(6-Benzyloxy-7-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2'] bipyridine (compound 138)

[0352] 6-Benzyloxy-4-chloro-7-methoxyquinoline (200 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (195 mg), and 4-dimethylaminopyridine (244 mg) were dissolved in dimethylsulfoxide (3 ml), cesium carbonate (655 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give the title compound (239 mg, yield 77%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.37 (s, 3H), 2.66 (s, 3H), 4.03 (s, 3H), 5.29 (s, 2H), 6.33 (d, J = 5.4 Hz, 1H), 7.08 (m, 1H), 7.30 - 7.39 (m, 5H), 7.47 (ddd, J = 2.0, 7.8, 7.8 Hz, 1H), 7.50 (m, 2H), 7.60 (s, 1H), 7.68 (d, J = 7.8 Hz, 1H), 8.38 (d, J = 5.4 Hz, 1H), 8.51 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 486 (M+Na)⁺

Example 139: 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-ol (compound 139)

[0353] 3-(6-Benzyloxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']-bipyridine (compound 136) (150 mg) was dissolved in trifluoroacetic acid (3 ml). Methanesulfonic acid (0.3 ml) was added to the solution, and the mixture was stirred at room temperature for one hr. Water was added to the reaction mixture, the mixture was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give the title compound (117 mg, yield 99%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.24 (s, 3H), 2.62 (s, 3H), 6.50 (d, J = 5.2 Hz, 1H), 7.13 (ddd, J = 1.2, 4.9, 7.9 Hz, 1H), 7.15 (s, 1H), 7.32 (m, 1H), 7.36 (dd, J = 2.8, 9.0 Hz, 1H), 7.51 (m, 1H), 7.66 (dd, J = 1.2, 8.0 Hz, 1H), 7.94 (d, J = 9.0 Hz, 1H), 8.45 (d, J = 5.2 Hz, 1H), 8.56 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 366 (M+Na)⁺

Example 140: 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-7-ol (compound 140)

[0354] 3-(7-Benzyloxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2'] bipyridine (compound 137) (230 mg) was dissolved in trifluoroacetic acid (3 ml). Methanesulfonic acid (0.3 ml) was added to the solution, and the mixture was stirred at room temperature for one hr. Water was added to the reaction mixture, the mixture was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (182 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.64 (s, 3H), 6.27 (d, J = 5.4 Hz, 1H), 6.87 (dd, J = 2.2, 9.0 Hz, 1H), 7.08 (dd, J = 4.9, 7.6 Hz, 1H), 7.23 (m, 1H), 7.40 (s, 1H), 7.58 (dd, J = 7.6, 7.8 Hz, 1H), 7.81 (d, J = 7.8 Hz, 1H), 7.99 (d, J = 9.0 Hz, 1H), 8.35 (d, J = 5.4 Hz, 1H), 8.50 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 344 (M+1)⁺

Example 141: 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-7-methoxy-quinolin-6-ol (compound 141)

[0355] 3-(6-Benzyloxy-7-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 138) (230 mg) was dissolved in trifluoroacetic acid (3 ml). Methanesulfonic acid (0.3 ml) was added to the solution, and the mixture was stirred at room temperature for one hr. Water was added to the reaction mixture, the mixture was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give the title compound (106 mg, yield 55%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.37 (s, 3H), 2.66 (s, 3H), 4.05 (s, 3H), 6.34 (d, J = 5.4 Hz, 1H), 7.11 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.32 (s, 1H), 7.38 (s, 1H), 7.56 (ddd, J = 1.7, 7.8, 7.8 Hz, 1H), 7.68 (s, 1H), 7.79 (ddd, J = 1.0, 1.2, 7.8 Hz, 1H), 8.37 (d, J = 5.1 Hz, 1H), 8.57 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 374 (M+1)⁺

Example 142: 2-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yloxy]-ethanol (compound 142)

[0356] 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-ol (compound 139) (88 mg) was dissolved in N,N-dimethylformamide (3 ml). Potassium carbonate (200 mg) and 2-bromoethanol (0.2 ml) were added to the solution, and the mixture was stirred at 70°C overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give the title compound (41 mg, yield 41%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.38 (s, 3H), 2.65 (s, 3H), 4.30 (t, J = 4.2 Hz, 2H), 4.23 (t, J = 4.4 Hz, 2H), 6.44 (d, J = 5.2 Hz, 1H), 7.11 (dd, J = 4.9, 7.6 Hz, 1H), 7.34 (s, 1H), 7.37 (m, 1H), 7.57 - 7.61 (m, 2H), 7.81 (d, J = 8.0 Hz, 1H), 7.95 (d, J = 9.0 Hz, 1H), 8.45 (d, J = 5.1 Hz, 1H), 8.49 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 410 (M+Na)⁺

Example 143: 2-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-7-yloxy]-ethanol (compound 143)

[0357] 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-7-ol (compound 140) (152 mg) was dissolved in N,N-dimeth-

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ylformamide (3 ml). Potassium carbonate (200 mg) and 2-bromoethanol (0.2 ml) were added to the solution, and the mixture was stirred at 70°C overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (93 mg, yield 54%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.66 (s, 3H), 4.05 (t, J = 4.2 Hz, 2H), 4.24 (t, J = 4.4 Hz, 2H), 6.33 (d, J = 5.4 Hz, 1H), 7.10 (dd, J = 4.9, 6.6 Hz, 1H), 7.22 (ddd, J = 1.2, 2.4, 9.3 Hz, 1H), 7.36 - 7.37 (m, 2H), 7.57 (ddd, J = 1.7, 7.8, 7.8 Hz, 1H), 7.80 (d, J = 7.8 Hz, 1H), 8.23 (d, J = 9.3 Hz, 1H), 8.48 - 8.49 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 410 (M+Na)⁺

Example 144: 2-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-7-methoxy-quinolin-6-yloxy]-ethanol (compound 144)

[0358] 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-7-methoxy-quinolin-6-ol (compound 141) (88 mg) was dissolved in N,N-dimethylformamide (3 ml). Potassium carbonate (200 mg) and 2-bromoethanol (0.2 ml) were added to the solution, and the mixture was stirred at 70°C overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give the title compound (59 mg, yield 67%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.38 (s, 3H), 2.65 (s, 3H), 4.00 (s, 3H), 4.04 (t, J = 4.4 Hz, 2H), 4.27 (t, J = 4.6 Hz, 2H), 6.37 (d, J = 5.4 Hz, 1H), 7.12 (dd, J = 4.9, 6.6 Hz, 1H), 7.33 (s, 1H), 7.37 (s, 1H), 7.58 (s, 1H), 7.59 (ddd, J = 2.0, 7.8, 7.8 Hz, 1H), 7.79 (d, J = 8.0 Hz, 1H), 8.40 (d, J = 5.4 Hz, 1H), 8.50 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 440 (M+Na)⁺

Example 145: 4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-6-methoxy-quinoline-7-carboxylic acid amide (compound 145)

[0359] Methyl 2-methoxy-5-nitro-benzoate (300 mg), ammonium chloride (228 mg), and zinc (929 mg) were suspended in ethanol (10 ml) and water (0.5 ml), and the suspension was stirred under reflux for 3 hr. The reaction mixture was filtered, and the solvent was removed from the filtrate by distillation under the reduced pressure. A saturated aqueous sodium hydrogencarbonate solution was added to the residue, and the mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give methyl 5-amino-2-methoxy-benzoate (244 mg, yield 95%).

Methyl 5-amino-2-methoxy-benzoate (244 mg) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (228 mg) were dissolved in 2-propanol (3 ml), and the mixture was stirred at 100°C for 15 hr. The solvent was removed by distillation under the reduced pressure, and the residue was washed with diethyl ether to give methyl 5-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidenemethyl)-amino]-2-methoxy-benzoate (248 mg, yield 55%).

[0360] Methyl 5-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidenemethyl)-amino]-2-methoxy-benzoate (245 mg) and biphenyl (676 mg) were suspended in diphenyl ether (2 ml), and the suspension was stirred at 260°C for 45 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with diethyl ether. The crystal thus obtained as such was used in the next reaction without further purification.

The crystal (45 mg) was suspended in thionyl chloride (1 ml), a minor amount of dimethylformamide was added to the suspension, and the mixture was stirred at 100°C for 3.5 hr. The reaction mixture was added to a saturated aqueous sodium hydrogencarbonate solution under ice cooling. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-chloroform system to give methyl 4-chloro-6-methoxy-quinoline-7-carboxylate (4 mg, yield 2%) (2 steps).

Methyl 4-chloro-6-methoxy-quinoline-7-carboxylate (99 mg) was dissolved in methanol (5 ml). A 28% aqueous ammonia solution (5 ml) was added to the solution, and the mixture was stirred at 40°C overnight. Methanol was removed by distillation under the reduced pressure, and ethyl acetate was added to the residue for extraction. The ethyl acetate layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give 4-chloro-6-methoxy-quinoline-carboxylic acid amide (85 mg, yield 91%).

[0361] 4-Chloro-6-methoxy-quinoline-carboxylic acid amide (41 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (87 mg), 4-dimethylaminopyridine (63 mg), and cesium carbonate (169 mg) were suspended in dimethylsulfoxide (2 ml), and the suspension was stirred at 120°C for 22 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to

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give the title compound (13 mg, yield 19%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.66 (s, 3H), 4.10 (s, 3H), 6.03 (brs, 1H), 6.46 (d, J = 5.2 Hz, 1H), 7.11 (m, 1H), 7.38 (s, 1H), 7.60 (m, 1H), 7.71 (m, 2H), 7.82 (d, J = 7.6 Hz, 1H), 8.44 (dd, J = 4.8, 0.8 Hz, 1H), 8.53 (d, J = 5.2 Hz, 1H), 8.89 (s, 1H)

5 Mass spectrometric value (ESI-MS, m/z): 423 (M+Na)⁺

Example 146: 7-Chloro-4-(5,6-dimethyl-[2,2']bipyridinyl-3-yloxy)-quinoline-6-carboxylic acid amide (compound 146)

10 **[0362]** 4-Amino-2-chloro-benzoic acid (2.50 g) and lithium hydroxide monohydrate (611 mg) were suspended in tetrahydrofuran (20 ml), and the suspension was stirred at room temperature for 20 min. Thereafter, dimethylsulfuric acid (1.38 ml) was added to the reaction mixture, and the mixture was stirred under reflux for 2 hr. The solvent was removed by distillation under the reduced pressure. Water was added to the residue, and the mixture was neutralized with a saturated aqueous sodium hydrogencarbonate solution and was extracted with diethyl ether. The diethyl ether layer was then washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure to give methyl 4-amino-2-chloro-benzoate (1.68 g, yield 62%).

15 Methyl 4-amino-2-chloro-benzoate (1.68 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.53 g) were dissolved in 2-propanol (25 ml), and the mixture was stirred at 100°C for 15.5 hr. The solvent was removed by distillation under the reduced pressure, and the residue was washed with diethyl ether to give methyl 2-chloro-4-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidene)methyl]-amino]-benzoate (1.92 g, yield 63%).

20 **[0363]** Methyl 2-chloro-4-[(2,2-dimethyl-4,6-dioxo-[1,3]dioxan-5-ylidene)methyl]-amino]-benzoate (1.81 g) and biphenyl (4.93 g) were suspended in diphenyl ether (12 ml), and the suspension was stirred at 260°C for 45 min. The reaction mixture was cooled to room temperature, and the precipitated crystal was collected by filtration and was washed with diethyl ether. The crystal thus obtained as such was used in the next reaction without further purification.

25 The crystal (1.21 g) was suspended in thionyl chloride (12 ml), a minor amount of N,N-dimethylformamide was added to the suspension, and the mixture was stirred at 100°C for 4 hr. The reaction mixture was added to a saturated aqueous sodium hydrogencarbonate solution under ice cooling. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-hexane system to give methyl 4,7-dichloro-quinoline-6-carboxylate (350 mg, yield 26%) (2 steps).

30 Methyl 4,7-dichloro-quinoline-6-carboxylate (197 mg) was dissolved in methanol (7 ml). A 28% aqueous ammonia solution (7 ml) was added to the solution, and the mixture was stirred at 40°C overnight. Methanol was removed by distillation under the reduced pressure, and ethyl acetate was added to the residue for extraction. The ethyl acetate layer was washed with water and saturated brine and was dried over magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give 4,7-dichloro-quinoline-6-carboxylic acid amide (145 mg, yield 78%).

35 **[0364]** 4,7-Dichloro-quinoline-6-carboxylic acid amide (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (83 mg), 4-dimethylaminopyridine (76 mg), and cesium carbonate (203 mg) were suspended in dimethylsulfoxide (2 ml), and the suspension was stirred at 120°C for 22 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (16 mg, yield 19%).

40 ¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.65 (s, 3H), 6.36 (brs, 1H), 6.44 (d, J = 5.2 Hz, 1H), 6.62 (brs, 1H), 7.08 (ddd, J = 7.2, 4.8, 1.2 Hz, 1H), 7.35 (s, 1H), 7.60 (m, 1H), 7.86 (m, 1H), 8.09 (s, 1H), 8.36 (m, 1H), 8.59 (d, J = 5.2 Hz, 1H), 8.76 (s, 1H)

45 Mass spectrometric value (ESI-MS, m/z): 427 (M+Na)⁺

Example 147: 6-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-7-carboxylic acid amide (compound 147)

50 **[0365]** 4-Chloro-6-methoxy-quinoline-7-carboxylic acid amide (21 mg), 2-phenyl-[1,8]naphthyridin-3-ol (49 mg), and 4-dimethylaminopyridine (33 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140°C for 3.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (26 mg, yield 69%). ¹H-NMR (CD₃OD, 400 MHz): δ 4.11 (s, 3H), 6.66 (d, J = 5.6 Hz, 1H), 7.32 (m, 3H), 7.70 (dd, J = 8.4, 4.4 Hz, 1H), 7.89 (s, 1H), 8.01 (m; 2H), 8.39 - 8.52 (m, 4H), 9.11 (d, J = 2.4 Hz, 1H)

55 Mass spectrometric value (ESI-MS, m/z): 445 (M+Na)⁺

Example 148: Methyl 7-chloro-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinoline-6-carboxylate (compound 148)

[0366] Methyl 4,7-dichloro-quinoline-6-carboxylate (46 mg), 2-phenyl-[1,8]naphthyridin-3-ol (100 mg), and 4-dimethylaminopyridine (66 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 140 °C for 3.5 hr. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with water and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a chloroform-methanol system to give the title compound (33 mg, yield 42%).

¹H-NMR (CDCl₃, 400 MHz): δ 4.03 (s, 3H), 6.44 (d, J = 5.2 Hz, 1H), 7.33 (m, 3H), 7.56 (dd, J = 8.0, 4.4 Hz, 1H), 8.07 (m, 3H), 8.15 (s, 1H), 8.21 (dd, J = 8.4, 2.0 Hz, 1H), 8.63 (d, J = 5.2 Hz, 1H), 8.89 (s, 1H), 9.19 (dd, J = 4.4, 2.0 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 464 (M+Na)⁺

Example 154: 2-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-7-methoxy-quinolin-6-ylamino]-ethanol (compound 154)

[0367] Palladium acetate (30 mg) and 2,2'-bis(diphenylphosphino)-1,1'-binaphthyl (80 mg) were dissolved in toluene (4 ml), and the solution was stirred at room temperature for 5 min. 3-(6-Bromo-7-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 133) (100 mg) and 2-aminoethanol (0.2 ml) were added thereto, and the mixture was stirred at room temperature for additional 5 min. Cesium carbonate (250 mg) was added to the reaction mixture, and the mixture was stirred at 80 °C for two days. Water was added to the reaction mixture, the mixture was extracted with chloroform, and the chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (9 mg, yield 9%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.27 (s, 3H), 2.56 (s, 3H), 3.35 (t, J = 5.4 Hz, 2H), 3.82 (t, J = 5.4 Hz, 2H), 3.88 (s, 3H), 6.32 (d, J = 5.1 Hz, 1H), 7.00 (m, 1H), 7.07 (ddd, J = 1.0, 4.9, 7.6 Hz, 1H), 7.19 - 7.20 (m, 2H), 7.52 (ddd, J = 1.7, 7.8, 8.1 Hz, 1H), 7.73 (d, J = 7.8 Hz, 1H), 8.21 (d, J = 5.1 Hz, 1H), 8.51 (m, 1H)
Mass spectrometric value (ESI-MS, m/z): 439 (M+Na)⁺

Example 155: 3-(7-Methoxy-6-pyridin-3-yl-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 155)

[0368] N,N-Dimethylformamide (3 ml) and a 2 M aqueous potassium carbonate solution (1.5 ml) were added to 3-(6-bromo-7-methoxy-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 133) (70 mg), tetrakis(triphenylphosphine) palladium (29 mg), and 3-pyridylboric acid (57 mg) under an argon atmosphere, and the mixture was stirred at 70 °C for 2 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give the title compound (56 mg, yield 80%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.66 (s, 3H), 3.98 (s, 3H), 6.35 (d, J = 5.4 Hz, 1H), 7.10 (dd, J = 5.8, 7.6 Hz, 1H), 7.36 - 7.39 (m, 2H), 7.48 (s, 1H), 7.59 (ddd, J = 1.7, 7.6, 7.8 Hz, 1H), 7.82 (d, J = 8.0 Hz, 1H), 7.95 (d, J = 7.8 Hz, 1H), 8.25 (s, 1H), 8.47 (m, 1H), 8.51 (d, J = 5.4 Hz, 1H), 8.61 (m, 1H), 8.85 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 457 (M+Na)⁺

Example 156: 3-(6-Chloro-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 156)

[0369] 4,6-Dichloro-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (51 mg), and 4-dimethylaminopyridine (93 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (247 mg) was added to the solution, and the mixture was stirred at 130 °C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (90 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.51 (d, J = 5.4 Hz, 1H), 7.11 (ddd, J = 1.0, 4.9, 7.6 Hz, 1H), 7.38 (s, 1H), 7.63 (ddd, J = 1.7, 7.8, 7.8 Hz, 1H), 7.73 (dd, J = 2.2, 8.8 Hz, 1H), 7.91 (d, J = 8.1 Hz, 1H), 8.15 (d, J = 8.8 Hz, 1H), 8.34 (m, 1H), 8.37 (d, J = 2.2 Hz, 1H), 8.56 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 384 (M+Na)⁺

Example 157: 5,6-Dimethyl-3-(6-methyl-quinolin-4-yloxy)-[2,2']bipyridine (compound 157)

[0370] 4-Chloro-6-methyl-quinoline (50 mg), 5,6-dimethyl-[2,2']bipyridinyl-3-ol (56 mg), and 4-dimethylaminopyridine

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(103 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (275 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (82 mg, yield 85%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.58 (s, 3H), 2.67 (s, 3H), 6.46 (d, J = 5.4 Hz, 1H), 7.10 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.36 (s, 1H), 7.60 (m, 1H), 7.64 (s, 1H), 7.89 (d, J = 7.8 Hz, 1H), 8.09 (d, J = 8.5 Hz, 1H), 8.15 (m, 1H), 8.40 (m, 1H), 8.51 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 364 (M+Na)⁺

Example 158: 4-(5,6-Dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6-fluoro-7-methoxy-quinoline (compound 158)

[0371] 4-Chloro-6-fluoro-7-methoxy-quinoline (13 mg), 5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-ol (12 mg), and 4-dimethylaminopyridine (22 mg) were dissolved in dimethylsulfoxide (1 ml), cesium carbonate (58 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (15 mg, yield 66%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.44 (s, 3H), 2.70 (s, 3H), 4.07 (s, 3H), 6.48 (d, J = 5.4 Hz, 1H), 7.12 (t, J = 4.9 Hz, 1H), 7.43 (s, 1H), 7.65 (m, 1H), 7.95 (d, J = 11.5 Hz, 1H), 8.48 (d, J = 5.6 Hz, 1H), 8.62 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 399 (M+Na)⁺

Example 159: 4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6-fluoro-7-methoxy-quinoline (compound 159)

[0372] 4-Chloro-6-fluoro-7-methoxy-quinoline (50 mg), 6-ethyl-2-pyrimidin-2-yl-pyridin-3-ol (48 mg), and 4-dimethylaminopyridine (84 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (231 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (54 mg, yield 60%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.42 (t, J = 7.8 Hz, 3H), 3.06 (q, J = 7.6 Hz, 2H), 4.06 (s, 3H), 6.51 (d, J = 5.4 Hz, 1H), 7.14 (t, J = 4.9 Hz, 1H), 7.45 (d, J = 8.1 Hz, 1H), 7.61 (m, 2H), 7.92 (d, J = 10.7 Hz, 1H), 8.50 (d, J = 5.4 Hz, 1H), 8.65 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 399 (M+Na)⁺

Example 160: 3-(6-Fluoro-7-methoxy-quinolin-4-yloxy)-2-methyl-[1,8]naphthyridine (compound 160)

[0373] 2-Methyl-[1,8]naphthyridin-3-ol (42 mg), 4-chloro-6-fluoro-7-methoxy-quinoline (50 mg), and 4-dimethylaminopyridine (87 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (63 mg, yield 78%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.73 (s, 3H), 4.11 (s, 3H), 6.49 (d, J = 5.4 Hz, 1H), 7.52 (dd, J = 4.4, 8.3 Hz, 1H), 7.74 (d, J = 7.8 Hz, 1H), 7.84 (s, 1H), 8.01 (d, J = 11.2 Hz, 1H), 8.15 (dd, J = 2.0, 8.1 Hz, 1H), 8.63 (d, J = 5.4 Hz, 1H), 9.14 (dd, J = 2.0, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 358 (M+Na)⁺

Example 161: 2-Ethyl-3-(6-fluoro-7-methoxy-quinolin-4-yloxy)-[1,8]naphthyridine (compound 161)

[0374] 2-Aminopyridine-3-carbaldehyde (100 mg) and 1-bromo-butan-2-one (124 mg) were suspended in a 5 N aqueous sodium hydroxide solution (0.6 ml), and the suspension was allowed to stand in a hermetically stoppered state for three days. The reaction mixture was neutralized with 10% hydrochloric acid, and the resultant precipitate was filtered, and the residue was washed with water and chloroform. The powder was dried in vacuo to give 2-ethyl-[1,8]naphthyridin-

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3-ol (106 mg, yield 74%).

2-Ethyl-[1,8]naphthyridin-3-ol (41 mg), 4-chloro-6-fluoro-7-methoxy-quinoline (50 mg), and 4-dimethylaminopyridine (87 mg) were suspended in 1,2-dichlorobenzene (1.5 ml), and the suspension was stirred at 130°C for 6.5 hr. The reaction mixture was cooled to room temperature, and an aqueous sodium hydrogencarbonate solution was added to the reaction mixture. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (38 mg, yield 46%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.45 (t, J = 7.6 Hz, 3H), 3.04 (q, J = 7.3 Hz, 2H), 4.10 (s, 3H), 6.50 (d, J = 5.4 Hz, 1H), 7.51 (dd, J = 4.4, 7.6 Hz, 1H), 7.69 (m, 1H), 7.82 (s, 1H), 7.99 (dd, J = 1.2, 11.2 Hz, 1H), 8.14 (dd, J = 1.5, 8.3 Hz, 1H), 8.63 (d, J = 5.4 Hz, 1H), 9.14 (ddd, J = 1.0, 2.0, 4.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 372 (M+Na)⁺

Example 162: 6-Ethyl-3-(6-fluoro-7-methoxy-quinolin-4-yloxy)-[2,2']bipyridine (compound 162)

[0375] 4-Chloro-6-fluoro-7-methoxy-quinoline (50 mg), 6-ethyl-[2,2']bipyridinyl-3-ol (52 mg), and 4-dimethylaminopyridine (87 mg) were dissolved in dimethylsulfoxide (1.5 ml), cesium carbonate (231 mg) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (84 mg, yield 93%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.42 (t, J = 7.8 Hz, 3H), 3.01 (q, J = 7.6 Hz, 2H), 4.06 (s, 3H), 6.43 (d, J = 5.6 Hz, 1H), 7.12 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.36 (d, J = 8.3 Hz, 1H), 7.56 (d, J = 8.3 Hz, 1H), 7.63 - 7.67 (m, 2H), 7.92 (d, J = 7.8 Hz, 1H), 7.96 (d, J = 11.5 Hz, 1H), 8.33 (d, J = 3.9 Hz, 1H), 8.47 (d, J = 5.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 398 (M+Na)⁺

Example 163: 5,6-Dimethyl-3-(6-thiophen-3-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 163)

[0376] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and thiophene-3-boric acid (28 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (30 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.39 (s, 3H), 2.67 (s, 3H), 6.45 (d, J = 5.1 Hz, 1H), 7.09 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.39 (s, 1H), 7.44 (dd, J = 5.1, 2.9 Hz, 1H), 7.54 - 7.60 (m, 2H), 7.64 (dd, J = 2.9, 1.5 Hz, 1H), 7.83 (ddd, J = 7.1, 1.0, 1.0 Hz, 1H), 8.00 (dd, J = 8.8, 2.0 Hz, 1H), 8.06 (d, J = 8.8 Hz, 1H), 8.47 - 8.51 (m, 1H), 8.52 - 8.56 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 410 (M+1)⁺

Example 164: 3-(6-Benzo[b]thiophen-3-yl-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 164)

[0377] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and thianaphthene-3-boric acid (39 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (34 mg, yield 100%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.66 (s, 3H), 6.50 (d, J = 5.1 Hz, 1H), 7.11 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.36 - 7.44 (m, 3H), 7.54 - 7.62 (m, 2H), 7.83 (ddd, J = 8.0, 1.0, 1.0 Hz, 1H), 7.92 - 8.01 (m, 3H), 8.16 (d, J = 8.6 Hz, 1H), 8.48 - 8.53 (m, 1H), 8.55 (d, J = 2.0 Hz, 1H), 8.61 (d, J = 5.1 Hz, 1H) Mass spectrometric value (ESI-MS, m/z): 482 (M+Na)⁺

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Example 165: 5,6-Dimethyl-3-[6-(5-methyl-thiophen-2-yl)-quinolin-4-yloxy]-[2,2']bipyridine (compound 165)

[0378] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and 5-methylthiophene-2-boric acid (31 mg) under an argon atmosphere, and the mixture was stirred at 70°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (4 mg, yield 13%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.55 (s, 3H), 2.67 (s, 3H), 6.43 (d, J = 4.9 Hz, 1H), 6.79 (d, J = 2.4 Hz, 1H), 7.06 - 7.14 (m, 1H), 7.29 (d, J = 3.2 Hz, 1H), 7.39 (s, 1H), 7.54 - 7.62 (m, 1H), 7.84 (d, J = 7.8 Hz, 1H), 7.95 (dd, J = 8.8, 2.0 Hz, 1H), 8.01 (d, J = 8.8 Hz, 1H), 8.45 (s, 1H), 8.47 - 8.55 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 424 (M+1)⁺

Example 166: 3-(6-Benzofuran-2-yl-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 166)

[0379] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and benzo[b]furan-2-boric acid (36 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (4 mg, yield 13%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.68 (s, 3H), 6.46 (d, J = 5.1 Hz, 1H), 7.08 (ddd, J = 8.8, 4.9, 1.2 Hz, 1H), 7.20 (d, J = 0.8 Hz, 1H), 7.23 - 7.34 (m, 2H), 7.41 (s, 1H), 7.51 - 7.65 (m, 3H), 7.89 (ddd, J = 7.8, 7.8, 1.0 Hz, 1H), 8.08 (d, J = 8.8 Hz, 1H), 8.17 (dd, J = 8.8, 2.0 Hz, 1H), 8.47 - 8.51 (m, 1H), 8.55 (d, J = 5.1 Hz, 1H), 8.87 (d, J = 1.8 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 466 (M+Na)⁺

Example 167: 2-[4-(5,6-Dimethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yl]-pyrrole-1-carboxylate tert-butyl ester (compound 167)

[0380] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and 1-(tert-butoxycarbonyl)pyrrole-2-boric acid (47 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (31 mg, yield 85%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.37 (s, 9H), 2.38 (s, 3H), 2.66 (s, 3H), 6.27 (dd, J = 3.2, 3.2 Hz, 1H), 6.31 - 6.35 (m, 1H), 6.45 (d, J = 5.1 Hz, 1H), 7.10 (dd, J = 7.1, 5.1 Hz, 1H), 7.34 (s, 1H), 7.38 - 7.43 (m, 1H), 7.57 (ddd, J = 7.8, 7.8, 1.2 Hz, 1H), 7.73 (dd, J = 8.8, 1.7 Hz, 1H), 7.82 (d, J = 7.8 Hz, 1H), 8.00 (d, J = 8.8 Hz, 1H), 8.31 (d, J = 1.7 Hz, 1H), 8.52 (d, J = 4.4 Hz, 1H), 8.56 (d, J = 5.2 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 515 (M+Na)⁺

Example 168: 5,6-Dimethyl-3-[6-(1H-pyrrol-2-yl)-quinolin-4-yloxy]-[2,2']bipyridine (compound 168)

[0381] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and 1-(tert-butoxycarbonyl)pyrrole-2-boric acid (47 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 5 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium

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carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (4 mg, yield 15%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.36 (s, 3H), 2.63 (s, 3H), 6.32 - 6.37 (m, 1H), 6.47 (d, J = 5.1 Hz, 1H), 6.70 - 6.74 (m, 1H), 6.94 - 6.98 (m, 1H), 7.08 - 7.15 (m, 1H), 7.29 (s, 1H), 7.60 (ddd, J = 7.8, 7.8, 1.2 Hz, 1H), 7.79 (d, J = 8.1 Hz, 1H), 7.95 (dd, J = 9.0, 2.2 Hz, 1H), 8.02 (d, J = 8.6 Hz, 1H), 8.36 (d, J = 1.7 Hz, 1H), 8.47 - 8.52 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 393 (M+1)⁺

Example 169: 5,6-Dimethyl-3-[6-(1H-pyrazol-4-yl)-quinolin-4-yloxy]-[2,2']bipyridine (compound 169)

[0382] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and 1H-pyrazole-4-boric acid pinacol ester (43 mg) under an argon atmosphere, and the mixture was stirred at 70°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (10 mg, yield 33%). ¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 6.45 (d, J = 5.1 Hz, 1H), 7.07 - 7.13 (m, 1H), 7.39 (s, 1H), 7.59 (ddd, J = 7.6, 7.6, 1.7 Hz, 1H), 7.84 (d, J = 7.8 Hz, 1H), 7.91 (dd, J = 8.8, 2.2 Hz, 1H), 8.03 (s, 2H), 8.06 (d, J = 8.8 Hz, 1H), 8.45 (d, J = 2.0 Hz, 1H), 8.48 - 8.51 (m, 1H), 8.53 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 394 (M+1)⁺

Example 170: 3-(6,7-Dimethyl-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 170)

[0383] 3,4-Dimethylaniline (3.0 g) was dissolved in 2-propanol (70 ml), and the mixture was stirred at 70°C for 10 min. 5-(Methoxymethylene)-2,2-dimethyl-[1,3]dioxan-4,6-dione (5.1 g) was added thereto, and the mixture was stirred at 70°C for one hr. The reaction mixture was cooled to room temperature, and the solvent was removed by distillation under the reduced pressure. The residue was suspended in diethyl ether, was collected by filtration, and was washed with diethyl ether. The crude crystal thus obtained as such was used in the next reaction without purification.

Diphenyl ether (50 ml) was added to the crude crystal obtained above and biphenyl (22.2 g), and the mixture was stirred at 240°C for 3 hr. The reaction mixture was cooled to room temperature. Diethyl ether and hexane were added to the cooled reaction mixture, and the resultant precipitate was collected by filtration and was washed with diethyl ether. The crude crystal thus obtained as such was used in the next reaction without purification.

[0384] Thionyl chloride (10 ml) and a minor amount of N,N-dimethylformamide were added to the crude crystal, and the mixture was stirred under reflux for 3 hr. The reaction mixture was added to a saturated aqueous sodium bicarbonate solution under ice cooling, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give 4-chloro-6,7-dimethylquinoline (1.07 g, yield 31%).

Dimethylsulfoxide (2 ml) was added to 5,6-dimethyl-[2,2']bipyridinyl-3-ol (40 mg), 4-chloro-6,7-dimethylquinoline (115 mg), cesium carbonate (196 mg), and 4-dimethylaminopyridine (73 mg), and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (27 mg, yield 38%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.36 (s, 3H), 2.48 (s, 3H), 2.65 (s, 3H), 2.79 (s, 3H), 6.48 (d, J = 4.9 Hz, 1H), 7.14 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.26 (s, 1H), 7.52 (d, J = 8.6 Hz, 1H), 7.61 (ddd, J = 7.6, 7.6, 1.9 Hz, 1H), 7.76 - 7.83 (m, 2H), 8.48 (d, J = 5.1 Hz, 1H), 8.53 - 8.58 (m, 1H)

Mass spectrometric value (ESI-MS, m/z): 378 (M+Na)⁺

Example 171: 5,6-Dimethyl-3-(7-thioahen-3-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 171)

[0385] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (30 mg), tetrakis(triphenyl)phosphine palladium (9 mg), and thiophene-3-boric acid (28 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 7 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted

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with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (18 mg, yield 59%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 6.41 (d, J = 5.4 Hz, 1H), 7.10 (ddd, J = 7.6, 4.6, 1.0 Hz, 1H), 7.39 (s, 1H), 7.46 (dd, J = 4.9, 3.0 Hz, 1H), 7.55 - 7.61 (m, 2H), 7.68 (dd, J = 2.9, 1.2 Hz, 1H), 7.81 - 7.86 (m, 2H), 8.26 (d, J = 1.7 Hz, 1H), 8.36 (d, J = 8.6 Hz, 1H), 8.48 - 8.52 (m, 1H), 8.57 (d, J = 5.4 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 410 (M+1)⁺

Example 172: 3-(7-Benzo[b]thiophen-3-yl-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 172)

[0386] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and thianaphthene-3-boric acid (39 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 7 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (33 mg, yield 96%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.68 (s, 3H), 6.47 (d, J = 5.1 Hz, 1H), 7.12 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.39 - 7.46 (m, 3H), 7.58 - 7.64 (m, 2H), 7.82 (dd, J = 8.6, 1.7 Hz, 1H), 7.87 (ddd, J = 7.8, 1.0, 1.0 Hz, 1H), 7.92 - 7.97 (m, 1H), 8.02 - 8.09 (m, 1H), 8.30 (d, J = 1.7 Hz, 1H), 8.45 (d, J = 8.8 Hz, 1H), 8.51 - 8.55 (m, 1H), 8.62 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 460 (M+1)⁺

Example 173: 3-(7-Benzofuran-2-yl-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 173)

[0387] N,N-Dimethylformamide (1 ml) and a 2 M aqueous potassium carbonate solution (0.5 ml) were added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (30 mg), tetrakis(triphenylphosphine) palladium (9 mg), and benzo[b]furan-2-boric acid (36 mg) under an argon atmosphere, and the mixture was stirred at 70°C for 7 hr. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-acetone system to give the title compound (26 mg, yield 78%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 6.43 (d, J = 5.1 Hz, 1H), 7.09 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.23 - 7.29 (m, 2H), 7.33 (ddd, J = 8.3, 8.3, 1.4 Hz, 1H), 7.40 (s, 1H), 7.55 - 7.61 (m, 2H), 7.64 (d, J = 7.6 Hz, 1H), 7.84 (ddd, J = 7.8, 1.2, 1.2 Hz, 1H), 8.03 (dd, J = 8.8, 1.7 Hz, 1H), 8.41 (d, J = 8.8 Hz, 1H), 8.46 - 8.51 (m, 1H), 8.54 (d, J = 1.4 Hz, 1H), 8.59 (d, J = 5.1 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 444 (M+1)⁺

Example 174: 5,6-Dimethyl-3-(6-pyridin-2-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 174)

[0388] N,N-Dimethylformamide (1 ml) was added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (25 mg), tetrakis(triphenylphosphine) palladium (7 mg), 2-tributylstannylpyridine (45 mg), and copper(II) oxide (1 mg) under an argon atmosphere, and the mixture was stirred at 100°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (12 mg, yield 46%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 6.46 (d, J = 5.1 Hz, 1H), 7.08 (ddd, J = 7.3, 4.6, 1.0 Hz, 1H), 7.27 - 7.32 (m, 1H), 7.39 (s, 1H), 7.56 (ddd, J = 7.8, 7.8, 1.9 Hz, 1H), 7.81 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.85 (d, J = 7.8 Hz, 1H), 7.94 (d, J = 8.1 Hz, 1H), 8.14 (d, J = 8.8 Hz, 1H), 8.44 (dd, J = 8.8, 2.0 Hz, 1H), 8.47 - 8.51 (m, 1H), 8.58 (d, J = 5.1 Hz, 1H), 8.74 - 8.79 (m, 1H), 8.96 (d, J = 2.0 Hz, 1H)

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Mass spectrometric value (ESI-MS, m/z): 405 (M+1)⁺

Example 175: 5,6-Dimethyl-3-(6-pyrimidin-2-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 175)

5 **[0389]** N,N-Dimethylformamide (1 ml) was added to 3-(6-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 2) (25 mg), tetrakis(triphenyl)phosphine palladium (7 mg), 2-tributylstannylpyrimidine (45 mg), and copper(II) oxide (1 mg) under an argon atmosphere, and the mixture was stirred at 100°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate.
10 The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (6 mg, yield 22%).
15 ¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.68 (s, 3H), 6.46 (d, J = 5.2 Hz, 1H), 7.07 (ddd, J = 7.6, 4.9, 1.0 Hz, 1H), 7.24 - 7.28 (m, 1H), 7.39 (s, 1H), 7.53 (ddd, J = 7.8, 7.8, 2.0 Hz, 1H), 7.88 (d, J = 8.1 Hz, 1H), 8.14 (d, J = 8.8 Hz, 1H), 8.48 - 8.53 (m, 1H), 8.60 (d, J = 5.1 Hz, 1H), 8.81 (dd, J = 8.8, 2.0 Hz, 1H), 8.88 (d, J = 4.9 Hz, 2H), 9.48 (d, J = 1.7 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 428 (M+Na)⁺

Example 176: 5,6-Dimethyl-3-(7-pyridin-2-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 176)

20 **[0390]** N,N-Dimethylformamide (1 ml) was added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (25 mg), tetrakis(triphenyl)phosphine palladium (7 mg), 2-tributylstannylpyridine (45 mg), and copper(II) oxide (1 mg) under an argon atmosphere, and the mixture was stirred at 100°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate.
25 The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (18 mg, yield 72%).
30 ¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.67 (s, 3H), 6.45 (d, J = 5.1 Hz, 1H), 7.08 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.28 - 7.34 (m, 1H), 7.42 (s, 1H), 7.56 (ddd, J = 7.8, 7.8, 1.7 Hz, 1H), 7.80 - 7.87 (m, 2H), 7.94 (d, J = 8.0 Hz, 1H), 8.35 (dd, J = 8.8, 1.7 Hz, 1H), 8.46 (d, J = 8.8 Hz, 1H), 8.47 - 8.51 (m, 1H), 8.58 (d, J = 1.5 Hz, 1H), 8.60 (d, J = 5.1 Hz, 1H), 8.75 - 8.80 (m, 1H)
Mass spectrometric value (ESI-MS, m/z): 427 (M+Na)⁺

Example 177: 5,6-Dimethyl-3-(7-pyrimidin-2-yl-quinolin-4-yloxy)-[2,2']bipyridine (compound 177)

35 **[0391]** N,N-Dimethylformamide (1 ml) was added to 3-(7-bromo-quinolin-4-yloxy)-5,6-dimethyl-[2,2']bipyridine (compound 14) (25 mg), tetrakis(triphenyl)phosphine palladium (7 mg), 2-tributylstannylpyrimidine (45 mg), and copper(II) oxide (1 mg) under an argon atmosphere, and the mixture was stirred at 100°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was then extracted with 1 N hydrochloric acid, and the aqueous layer was washed with ethyl acetate. The aqueous layer was rendered alkaline by the addition of potassium carbonate and was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was then dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a hexane-acetone system to give the title compound (6 mg, yield 24%).
40 ¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.67 (s, 3H), 6.46 (d, J = 5.2 Hz, 1H), 7.08 (ddd, J = 7.6, 4.9, 1.2 Hz, 1H), 7.25 - 7.29 (m, 1H), 7.42 (s, 1H), 7.56 (ddd, J = 7.6, 7.6, 1.7 Hz, 1H), 7.84 (d, J = 8.0 Hz, 1H), 8.44 - 8.51 (m, 2H), 8.61 (d, J = 2.7 Hz, 1H), 8.63 (d, J = 2.4 Hz, 1H), 8.90 (d, J = 4.9 Hz, 2H), 9.16 (d, J = 1.4 Hz, 1H)
45 Mass spectrometric value (ESI-MS, m/z): 428 (M+Na)⁺

Examples 178 to 225

50 **[0392]** Compounds of Examples 178 to 225 were produced according to the above schemes. The names of compounds produced in these Examples and the measured values of the molecular weight of the actually produced compounds were as shown in Table A which will be described later.
For typical examples thereof, specific production processes will be described.

Example 178: 2-[6-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinolin-7-yloxy]-ethanol (compound 178)

[0393] 2-Phenyl-[1,8]naphthyridin-3-ol (6.61 g), 7-benzyloxy-4-chloro-6-methoxy-quinoline (16.6 g), and 4-dimethylaminopyridine (10.9 g) were suspended in 1,2-dichlorobenzene (80 ml), and the suspension was stirred at 140 °C for 20 hr. The solvent was removed by distillation under the reduced pressure. Water was added to the residue, and the mixture was extracted with chloroform. The chloroform layer was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give 3-(7-benzyloxy-6-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (6.00 g, yield 42%).

3-(7-Benzyloxy-6-methoxy-quinolin-4-yloxy)-2-phenyl-[1,8]naphthyridine (4.36 g) was dissolved in trifluoroacetic acid (40 ml), methanesulfonic acid (3 ml) was added to the solution, and the mixture was stirred at 80 °C for one hr. Water was added to the reaction mixture, the mixture was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure to give 6-methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinolin-7-ol (3.55 g, yield 100%).

[0394] 6-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yloxy)-quinolin-7-ol (3.55 g) was dissolved in N,N-dimethylformamide (30 ml). Potassium carbonate (6.20 g) and 2-bromoethanol (5.61 g) were added to the solution, and the mixture was stirred at 60 °C overnight. The solvent was removed by distillation under the reduced pressure. Water was added to the residue, and the mixture was extracted with chloroform. The chloroform layer was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give the title compound (3.20 g, yield 81%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.33 (m, 1H), 3.98 (s, 3H), 4.10 (m, 2H), 4.30(t, J = 4.8 Hz, 2H), 6.52 (d, J = 5.2 Hz, 1H), 7.37 (m, 3H), 7.44 (s, 1H), 7.48 (s, 1H), 7.92 (dd, J = 8.0, 4.0 Hz, 1H), 7.93 (s, 1H), 8.16 (m, 3H), 8.49 (d, J = 5.2 Hz, 1H), 9.16 (dd, J = 4.0, 2.0 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 462 (M+Na)⁺

Example 181: 2-[4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yloxy]-ethanol (compound 181)

[0395] 2-Bromopyridine (500 mg) was dissolved in tetrahydrofuran (15 ml). A 1.58 M n-butyllithium/hexane solution (2 ml) was added to the solution, and the mixture was stirred at -78 °C for 30 min. 5-Ethylfurfural (350 mg) was added to the reaction mixture, and the mixture was stirred at room temperature for additional one hr. Water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (5-ethyl-furan-2-yl)-pyridin-2-yl-methanol (214 mg, yield 37%).

(5-Ethyl-furan-2-yl)-pyridin-2-yl-methanol (214 mg) was dissolved in chloroform (5 ml), manganese dioxide (1.37 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered, and the solvent was removed by distillation under the reduced pressure. The residue was purified by thin layer chromatography with an ethyl acetate-hexane system to give (5-ethyl-furan-2-yl)-pyridin-2-yl-methanone (161 mg, yield 76%).

[0396] (5-Ethyl-furan-2-yl)-pyridin-2-yl-methanone (160 mg) was dissolved in methanol (3 ml), 28% aqueous ammonia (3 ml) was added to the solution, and the mixture was stirred in a sealed tube at 160 °C overnight. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-hexane system to give 6-ethyl-[2,2']bipyridin-3-ol (104 mg, yield 65%).

6-Benzyloxy-4-chloro-quinoline (3.47 g) and 6-ethyl-[2,2']bipyridin-3-ol (5.03 g) were dissolved in dimethylsulfoxide (25 ml), cesium carbonate (16.0 g) was added to the solution, and the mixture was stirred at 140 °C overnight. The reaction mixture was cooled to room temperature. Water was added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue as such was used in the next reaction without purification.

The crude product prepared above was dissolved in trifluoroacetic acid (10 ml). Methanesulfonic acid (2 ml) was added to the solution, and the mixture was stirred at room temperature for 2 hr and then at 80 °C for 7 hr. The reaction mixture was concentrated under the reduced pressure. Water was added to the reaction mixture, and the mixture was neutralized with an aqueous sodium hydrogencarbonate solution. The purified insolubles were collected by filtration and were washed with ethyl acetate to give 4-(6-ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-ol (2.57 g, yield 58%).

[0397] 4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-ol (2.57 g) was dissolved in N,N-dimethylformamide (25 ml). Potassium carbonate (9.08 g) and 2-bromoethanol (7.0 ml) were added to the solution, and the mixture was stirred at 80 °C overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed

by distillation under the reduced pressure, and the residue was washed with diethyl ether to give the title compound (1.29 g, yield 44%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.41(t, J = 7.8 Hz, 3H), 2.17 (m, 1H), 3.01(q, J = 7.8 Hz, 2H), 4.04 (m, 2H), 4.24 (t, J = 4.9 Hz, 2H), 6.45 (d, J = 5.1 Hz, 1H), 7.13 (ddd, J = 1.2, 4.9, 7.6 Hz, 1H), 7.34 (d, J = 8.3 Hz, 1H), 7.40 (dd, J = 2.9, 9.3 Hz, 1H), 7.54 (d, J = 8.3 Hz, 1H), 7.60 (d, J = 2.9 Hz, 1H), 7.62 (ddd, J = 1.9, 7.8, 7.8 Hz, 1H), 7.84 (d, J = 8.0 Hz, 1H), 7.96 (d, J = 9.2 Hz, 1H), 8.45 - 8.48 (m, 2H)

Mass spectrometric value (ESI-MS, m/z): 410 (M+Na)⁺

Example 188: 4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6,7-dimethoxy-quinoline (compound 188)

[0398] 2-Methylfuran (4.92 g) was dissolved in anhydrous ether (80 ml). A 1.58 M n-butyllithium/hexane solution (31.6 ml) was added to the solution at 0°C, and the mixture was stirred for 3 hr. The reaction mixture was cooled to -78°C. An ether solution (80 ml) of 2-cyanopyrimidine (5.78 g) was added to the reaction mixture, and the mixture was stirred at -78°C for additional 4 hr. The reaction mixture was rendered weakly acidic by the addition of 10% hydrochloric acid, and the mixture was then stirred at room temperature for 30 min. The reaction mixture was neutralized with potassium carbonate. The organic layer was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-hexane system to give (5-methylfuran-2-yl)-(2-pyrimidyl)-methanone (3.2 g, yield 34%).

(5-Methylfuran-2-yl)-(2-pyrimidyl)-methanone (3.2 g), methanol (10 ml), and a 28% aqueous ammonia solution (20 ml) were placed in a sealed tube, and the mixture was stirred at 160°C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-acetone system to give 6-methyl-2-pyrimidin-2-yl-pyridin-3-ol (1.32 g, yield 50%).

[0399] 4-Chloro-6,7-dimethoxy-quinoline (790 mg) and 6-methyl-2-pyrimidin-2-yl-pyridin-3-ol (660 mg) were dissolved in dimethylsulfoxide (4 ml), cesium carbonate (3.45 g) was added to the solution, and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the organic layer was then washed with saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system and was further purified by thin layer chromatography with a methanol-chloroform system to give the title compound (438 mg, yield 33%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.76 (s, 3H), 4.02 (s, 3H), 4.05 (s, 3H), 6.46 (d, J = 5.4 Hz, 1H), 7.14 (t, J = 4.9 Hz, 1H), 7.42 (d, J = 8.3 Hz, 1H), 7.48 (s, 1H), 7.54 (s, 1H), 7.58 (d, J = 8.3 Hz, 1H), 8.41 (d, J = 5.4 Hz, 1H), 8.66 (d, J = 4.9 Hz, 2H)
Mass spectrometric value (ESI-MS, m/z): 397 (M+Na)⁺

Example 192: 2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethanol (compound 192),

[0400] To anhydrous tetrahydrofuran (100 ml) were added a 2.0 M lithium diisopropylamide/heptane, tetrahydrofuran, an ethylbenzene solution (26.2 ml), and tri-n-butyltin hydride (14.1 ml) in that order under an argon atmosphere at 0°C. The mixture was stirred at 0°C for 15 min. The reaction mixture was cooled to -78°C. 2-Chloropyrimidine (5.0 g) dissolved in anhydrous tetrahydrofuran (20 ml) was added dropwise to the cooled reaction mixture. The mixture was slowly brought to room temperature and was stirred overnight. Water was added to the reaction mixture to stop the reaction. The mixture was filtered through Celite, and the filtrate was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give 2-tri-n-butylstannylpyrimidine (9.1 g, yield 56%).

2-Tri-n-butylstannylpyrimidine (5.0 g) was dissolved in tetrahydrofuran (130 ml) under an argon atmosphere. A 1.6 M n-butyllithium/hexane solution (8.6 ml) was added dropwise to the solution at -78°C, and the mixture was stirred at -78°C for 30 min. 4,5-Dimethylfurfural (1.85 g) dissolved in tetrahydrofuran (20 ml) was added dropwise to the solution, and the mixture was brought to room temperature with stirring. Water was added to the reaction mixture to stop the reaction. The solvent was removed by distillation under the reduced pressure, and water was added to the residue. The mixture was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a hexane-ethyl acetate system to give (5-ethylfuran-2-yl)-pyrimidin-2-yl-methanol (888 mg, yield 32%).

(5-Ethylfuran-2-yl)-pyrimidin-2-yl-methanol (880 mg) was dissolved in chloroform (15 ml), manganese dioxide (3.8 g) was added to the solution, and the mixture was stirred at room temperature overnight. The reaction mixture was filtered through Celite, and the solvent was removed from the filtrate by distillation under the reduced pressure. The residue was used in the next reaction without purification.

The residue, methanol (7 ml), and a 28% aqueous ammonia solution (8 ml) were placed in a sealed tube, and the mixture was stirred at 160 °C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-acetone system to give 6-ethyl-2-pyrimidin-2-yl-pyridin-3-ol (305 mg, yield 35%).

[0401] 6-Benzyloxy-4-chloro-quinoline (1.00 g), 6-ethyl-2-pyrimidin-2-yl-pyridin-3-ol (746 mg), and 4-dimethylaminopyridine (1.36 g) were dissolved in dimethylsulfoxide (5 ml), cesium carbonate (3.62 g) was added to the solution, and the mixture was stirred at 130 °C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The organic layer was extracted with chloroform, and the organic layer was then washed with saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system and further purified by thin layer chromatography with a methanol-chloroform system to give 6-benzyloxy-4-(6-ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (1.25 g, yield 77%).

6-Benzyloxy-4-(6-ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (1.25 g) was dissolved in trifluoroacetic acid (7 ml). Methanesulfonic acid (0.7 ml) was added to the solution, and the mixture was stirred at 70 °C for 2 hr. The reaction mixture was concentrated under the reduced pressure. Water was added to the reaction mixture, and the mixture was neutralized with an aqueous sodium hydrogencarbonate solution. The organic layer was extracted with chloroform, and the organic layer was then washed with saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give 4-(6-ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol (990 mg, yield 100%).

[0402] 4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol (990 mg) was dissolved in N,N-dimethylformamide (6 ml). Potassium carbonate (1.35 g) and 2-bromoethanol (0.7 ml) were added to the solution, and the mixture was stirred at 70 °C overnight. The reaction mixture was concentrated under the reduced pressure. Water was added to the residue, and the organic layer was extracted with chloroform. The organic layer was then washed with saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with an acetone-chloroform system to give the title compound (789 mg, yield 71%).

¹H-NMP, (CDCl₃, 400 MHz): δ 1.41 (t, J = 7.8 Hz, 3H), 2.19 (m, 1H), 3.05 (q, J = 7.8 Hz, 2H), 4.04 (m, 2H), 4.22 (t, J = 4.2 Hz, 2H), 6.56 (d, J = 5.4 Hz, 1H), 7.14 (t, J = 4.9 Hz, 1H), 7.41 - 7.45 (m, 2H), 7.58 - 7.61 (m, 2H), 8.05 (d, J = 9.0 Hz, 1H), 8.48 (d, J = 5.4 Hz, 1H), 8.66 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 411 (M+Na)⁺

Example 200: 2-[4-(5,6-Dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethanol (compound 200)

[0403] 2,3-Dimethylfuran (1.5 g) was dissolved in diethyl ether (20 ml) under an argon atmosphere. A 1.6 M n-butyllithium/hexane solution (10.9 ml) was added dropwise to the solution at 0 °C, and the mixture was stirred under reflux for 2.5 hr. Thereafter, the reaction mixture was cooled to -78 °C. 2-Cyanopyrimidine (1.8 g) dissolved in diethyl ether (8 ml) was added dropwise to the cooled reaction mixture, and the mixture was stirred at room temperature overnight. The reaction mixture was poured into ice to stop the reaction, was acidified with 1 M hydrochloric acid, and was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate.

The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-acetone system to give (4,5-dimethylfuran-2-yl)-(2-pyrimidyl)-methanone (226 mg, yield 7%). (4,5-Dimethylfuran-2-yl)-(2-pyrimidyl)-methanone (220 mg), methanol (2 ml), and a 28% aqueous ammonia solution (2 ml) were placed in a sealed tube, and the mixture was stirred at 160 °C overnight. The reaction mixture was cooled to room temperature, and the solvent was then removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-acetone system to give 5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-ol (129 mg, yield 59%).

[0404] 6-Benzyloxy-4-chloro-quinoline (1.30 g) and 5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-ol (1.46 g) were dissolved in dimethylsulfoxide (15 ml), cesium carbonate (4.71 g) was added thereto, and the mixture was stirred at 130 °C overnight. The reaction mixture was cooled to room temperature. Water was then added to the reaction mixture, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an acetone-hexane system to give 6-benzyloxy-4-(5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (1.52 g, yield 73%).

6-Benzyloxy-4-(5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (773 mg) was dissolved in trifluoroacetic acid (3 ml). Methanesulfonic acid (0.3 ml) was added to the solution, and the mixture was stirred at room temperature for 4 hr. Water was added to the reaction mixture, and the mixture was neutralized with an aqueous sodium hydrogencarbonate solution. The organic layer was extracted with ethyl acetate, and the ethyl acetate layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the

reduced pressure, and the residue was washed with diethyl ether to give 4-(5,6-dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol (467 mg, yield 76%).

[0405] 4-(5,6-Dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol (439 mg) was dissolved in N,N-dimethylformamide (5 ml). Potassium carbonate (0.89 g) and 2-bromoethanol (0.27 ml) were added to the solution, and the mixture was stirred at 80 °C for 5.5 hr. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (159 mg, yield 32%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 2.69 (s, 3H), 4.03 (t, J = 4.4 Hz, 2H), 4.23 (t, J = 4.9 Hz, 2H), 6.49 (d, J = 5.2 Hz, 1H), 7.10 (t, J = 4.9 Hz, 1H), 7.38 - 7.41 (m, 2H), 7.60 (d, J = 3.0 Hz, 1H), 7.96 (d, J = 9.3 Hz, 1H), 8.46 (d, J = 5.2 Hz, 1H), 8.65 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 411 (M+Na)⁺

Example 202: 2-[4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethanol (compound 202)

[0406] 6-Benzyloxy-4-chloro-quinoline (2.73 g), 6-methyl-2-pyrimidin-2-yl-pyridin-3-ol (949 mg), and cesium carbonate (4.96 g) were suspended in dimethylsulfoxide (25 ml), and the suspension was stirred at 130 °C overnight. The reaction mixture was cooled to room temperature, and water was added thereto. The mixture was extracted with chloroform, and the chloroform layer was washed with saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a chloroform-methanol system to give 6-benzyloxy-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (1.64 g, yield 77%).

6-Benzyloxy-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline (1.64 g) was dissolved in trifluoroacetic acid (30 ml). Methanesulfonic acid (2.5 ml) was added to the solution, and the solution was stirred at 80 °C for one hr. Water was added to the reaction mixture, the mixture was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with chloroform. The chloroform layer was washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure to give 4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol (1.28 g, yield 99%).

[0407] 4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol (1.10 g) was dissolved in N,N-dimethylformamide (10 ml). Potassium carbonate (1.85 g), N,N,N,N-tetrabutylammonium iodide (124 mg), and 2-bromoethanol (1.47 g) were added to the solution, and the mixture was stirred at 40 °C for 20 hr. The solvent was removed by distillation under the reduced pressure. Water was added to the residue, and the mixture was extracted with chloroform. The chloroform layer was dried over anhydrous magnesium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with a methanol-chloroform system to give the title compound (745 mg, yield 59%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.74 (s, 3H), 4.03 (t, J = 4.4 Hz, 2H), 4.21 (t, J = 4.4 Hz, 2H), 6.50 (d, J = 5.2 Hz, 1H), 7.12 (t, J = 4.8 Hz, 1H), 7.36 (dd, J = 9.6, 2.8 Hz, 1H), 7.39 (d, J = 8.4 Hz, 1H), 7.55 (d, J = 8.4 Hz, 1H), 7.57 (d, J = 2.8 Hz, 1H), 7.94 (d, J = 9.6 Hz, 1H), 8.46 (d, J = 5.2 Hz, 1H), 8.66 (d, J = 4.8 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 397 (M+Na)⁺

Example 205: 2-[4-(6-Methyl-[2,2']bipyridyl-3-yloxy)-quinolin-6-yloxy]-ethanol (compound 205)

[0408] 6-Iodo-2-picolin-5-ol (10.0 g) was dissolved in N,N-dimethylformamide (100 ml). Benzyl bromide (7.50 g) and potassium carbonate (17.6 g) were added to the solution, and the mixture was stirred at room temperature for 6 hr. The reaction mixture was filtered, water was added to the filtrate, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was washed with water and was dried over sodium sulfate, and the solvent was removed by distillation under the reduced pressure. The residue was used in the next reaction without purification.

The residue and dichlorobis(triphenylphosphine)-palladium(II) (1.50 g) were dissolved in anhydrous tetrahydrofuran (200 ml) under an argon atmosphere. A 0.5 M 2-pyridylzinc bromide/tetrahydrofuran solution (100 ml) was added to the solution, and the mixture was stirred under reflux overnight. The reaction mixture was cooled to room temperature, and the solvent was removed by distillation under the reduced pressure. A 1 N sodium hydroxide solution was added to the residue, and the mixture was extracted with chloroform. The chloroform layer was washed with water and was then dried over sodium sulfate, and the solvent was removed by distillation under the reduced pressure. The residue was used in the next reaction without purification.

Trifluoroacetic acid (40 ml) and methanesulfonic acid (2 ml) were added to the residue, and the mixture was stirred at 100 °C overnight. The reaction mixture was cooled to room temperature, and the solvent was removed by distillation under the reduced pressure. The residue was neutralized with a saturated aqueous sodium bicarbonate solution and was then filtered. The filtrate was extracted with ethyl acetate, and the ethyl acetate layer was washed with water and

was extracted with 1 N hydrochloric acid. The aqueous layer was washed with ethyl acetate and was then neutralized by the addition of a saturated aqueous sodium bicarbonate solution. The aqueous layer was extracted with ethyl acetate, was washed with water and was dried over sodium sulfate, and the solvent was removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-ethyl acetate system to give 6-methyl-[2,2']

bipyridyl-3-ol (5.09 g, yield 64%) (3 steps).

[0409] 4-Benzyloxy-phenylamine hydrochloride (1.18 g) and 5-methoxymethylene-2,2-dimethyl-[1,3]dioxan-4,6-dione (1.03 g) were suspended in 2-propanol (15 ml). Triethylamine (0.78 ml) was added to the suspension, and the mixture was stirred at 70°C for 3 hr. The reaction mixture was cooled to room temperature, was filtered and was washed with ether. The residue as such was used in the next reaction without purification.

The residue and biphenyl (4.34 g) were suspended in diphenyl ether (12 ml), and the suspension was stirred at 240°C overnight. The reaction mixture was cooled to room temperature, and the cooled reaction mixture as such was applied to column chromatography with a methanol-chloroform system. The crude product as such was used in the next reaction without further purification.

The crude product was suspended in diisopropylethylamine (3 ml), phosphorus oxychloride (0.5 ml) was added to the suspension, and the mixture was stirred at 120°C for 3hr. Water was added to the reaction mixture under ice cooling. The aqueous layer was neutralized with an aqueous sodium hydrogencarbonate solution, and the organic layer was extracted with ethyl acetate. The ethyl acetate layer was then washed with water and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography with an ethyl acetate-hexane system to give 6-benzyloxy-4-chloro-quinoline (147 mg, yield 10%) (3 steps).

[0410] Anhydrous dimethylsulfoxide (25 ml) was added to 6-methyl-[2,2']bipyridyl-3-ol (2.00 g), 6-benzyloxy-4-chloroquinoline (5.79 g), and cesium carbonate (7.00 g), and the mixture was stirred at 130°C overnight. The reaction mixture was cooled to room temperature. Water was added to the cooled reaction mixture, and the mixture was extracted with chloroform. The chloroform layer was washed with water and was dried over sodium sulfate, and the solvent was removed by distillation under the reduced pressure. The residue was purified by column chromatography with a hexane-acetone system to give 3-(6-benzyloxy-quinolin-4-yloxy)-6-methyl-[2,2']bipyridyl (3.38 g, yield 75%).

Trifluoroacetic acid (10 ml) and methanesulfonic acid (0.5 ml) were added to 3-(6-benzyloxy-quinolin-4-yloxy)-6-methyl-[2,2']bipyridyl (3.36 g), and the mixture was stirred under reflux for 6 hr. The solvent was removed by distillation under the reduced pressure. The residue was neutralized by the addition of a saturated aqueous sodium bicarbonate solution. Chloroform was added thereto, and the resultant precipitate was collected by filtration and was washed with water and chloroform to give crystals. The filtrate was subjected to separation, and the chloroform layer was washed with water and was then dried over sodium sulfate. The solvent was removed by distillation under the reduced pressure. The residue was purified by column chromatography with a chloroform-methanol system. The purified product was combined with the above crystals to give 4-(6-methyl-[2,2']bipyridyl-3-yloxy)-quinolin-6-ol (2.42 g, yield 92%).

[0411] N,N-Dimethylformamide (40 ml) was added to 4-(6-methyl-[2,2']bipyridyl-3-yloxy)-quinolin-6-ol (2.42 g), potassium carbonate (3.05 g), and 2-bromoethanol (2.76 g), and the mixture was stirred at 60°C overnight. The reaction mixture was cooled to room temperature, water was added to the cooled mixture, and the mixture was extracted with ethyl acetate. The ethyl acetate layer was dried over sodium sulfate, and the solvent was removed by distillation under the reduced pressure. The residue was purified by column chromatography with a chloroform-methanol system to give the title compound (1.19 g, yield 43%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.33(bs, 1H), 2.73 (s, 3H); 4.04 (m, 2H), 4.23 (t, J = 4.2 Hz, 2H), 6.45 (d, J = 5.1 Hz, 1H), 7.14 (dd, J = 7.6, 4.9 Hz, 1H), 7.32 (d, J = 8.3 Hz, 1H), 7.40 (dd, J = 2.7, 9.3 Hz, 1H), 7.51 (d, J = 8.3 Hz, 1H), 7.57 - 7.65 (m, 2H), 7.80 (d, J = 7.3 Hz, 1H), 7.96 (d, J = 9.3 Hz, 1H), 8.46 (d, J = 5.1 Hz, 1H), 8.52 (m, J = 4.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 374 (M+1)⁺

Example 206: 2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethyl acetate (compound 206)

[0412] 2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethanol (compound 192) (210 mg) was dissolved in dichloromethane (5 ml). Triethylamine (0.75 ml) and acetic anhydride (0.15 ml) were added to the solution under ice cooling, and the mixture was stirred at room temperature for 3 hr. Water was added to the reaction mixture, and the mixture was neutralized with an aqueous sodium hydrogencarbonate solution. The organic layer was extracted with ethyl acetate, and the organic layer was then washed with saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by thin layer chromatography with a methanol-chloroform system to give the title compound (202 mg, yield 87%).

¹H-NMR (CDCl₃, 400 MHz): δ 1.41 (t, J = 7.8 Hz, 3H), 2.12 (s, 3H), 3.04 (q, J = 7.6 Hz, 2H), 4.31 (t, J = 4.9 Hz, 2H), 4.49 (t, J = 4.9 Hz, 2H), 6.52 (d, J = 5.1 Hz, 1H), 7.13 (t, J = 4.9 Hz, 1H), 7.38 - 7.44 (m, 2H), 7.56 - 7.59 (m, 2H), 7.96 (d, J = 9.3 Hz, 1H), 8.48 (d, J = 5.1 Hz, 1H), 8.67 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 453 (M+Na)⁺

Example 209: 4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6-(2-morpholin-4-yl-ethoxy)-quinoline (compound 209)

[0413] 4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol (1.03 g) was dissolved in N,N-dimethylformamide (15 ml). Potassium carbonate (1.60 g) and 2-bromo-1-chloroethane (1.5 ml) were added to the solution, and the mixture was stirred at 65°C overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The organic layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography on silica gel with an ethyl acetate-hexane system to give 6-(2-chloro-ethoxy)-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline as a crude product (741 mg).

A part (103 mg) of the crude product was dissolved in N,N-dimethylformamide (2 ml). Potassium carbonate (240 mg) and morpholine (0.2 ml) were added to the solution, and the mixture was stirred at 80°C overnight. Water was added to the reaction mixture, and the mixture was extracted with ethyl acetate. The organic layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed by distillation under the reduced pressure, and the residue was purified by column chromatography on silica gel with an acetone-chloroform system to give the title compound (24 mg, yield 12%) (2 steps).

¹H-NMR (CDCl₃, 400 MHz): δ 2.60 - 2.62 (m, 4H), 2.76 (s, 3H), 2.87 (t, J = 5.6 Hz, 2H), 3.73 - 3.75 (m, 4H), 4.24 (t, J = 5.6 Hz, 2H), 6.50 (d, J = 5.4 Hz, 1H), 7.13 (t, J = 4.9 Hz, 1H), 7.37 - 7.41 (m, 2H), 7.54 - 7.57 (m, 2H), 7.94 (d, J = 9.3 Hz, 1H), 8.46 (d, J = 5.2 Hz, 1H), 8.67 (d, J = 4.9 Hz, 2H)

Mass spectrometric value (ESI-MS, m/z): 466 (M+Na)⁺

Reference Examples

[0414] Synthesis schemes and Synthesis Examples of quinoline derivatives or quinazoline derivatives, that is, compounds r1 to r469, having structures close to those of the compounds according to the present invention will be described. Typical Synthesis Examples in each of the following schemes will be described. Other compounds in each of the schemes could easily be produced by a person having ordinary skill in the art according to the procedure of each scheme and the description of typical Synthesis Examples in each of the schemes.

[0415] Reference Production Example 1 shows a production example of intermediate r1 in scheme r3. Reference Production Example 2 shows a production examples of intermediate r2 in scheme r4. Reference Production Examples 3 and 4 show production examples of intermediates r3 and r4 in scheme r5.

Reference Production Example 1: 2-[(6,7-Dimethoxy-4-quinolyl)oxy]-5-methylbenzaldehyde (intermediate r1)

[0416] 4-Chloro-6,7-dimethoxyquinoline (113 mg), 2-hydroxy-5-methylbenzaldehyde (344 mg), and 4-dimethylaminopyridine (313 mg) were suspended in o-dichlorobenzene (5 ml), and the suspension was stirred at 160°C for 2 hr. The reaction mixture was cooled to room temperature, and the solvent was then removed from the reaction mixture by distillation under the reduced pressure. Chloroform was added to the residue. The organic layer was washed with a 1 N aqueous sodium hydroxide solution and saturated brine and was dried over anhydrous magnesium sulfate. The solvent was removed from the reaction mixture by distillation under the reduced pressure. The residue was purified by column chromatography with a chloroform system to give the title compound (157 mg, yield 96%).

¹H-NMR (CDCl₃, 400 MHz): δ 2.46 (s, 3H), 4.06 (s, 3H), 4.06 (s, 3H), 6.44 (d, J = 5.1 Hz, 1H), 7.10 (d, J = 8.3 Hz, 1H), 7.45 (s, 1H), 7.49 (m, 1H), 7.57 (s, 1H), 7.83 (d, J = 1.9 Hz, 1H), 8.51 (d, J = 1.5 Hz, 1H), 10.28 (s, 1H)

Mass spectrometric value (ESI-MS, m/z): 324 (M+1)⁺

Reference Production Example 2: 2-(6,7-Dimethoxyquinolin-4-yloxy)-5-methoxybenzoic acid (intermediate r2)

[0417] Ethyl 2-(6,7-dimethoxyquinolin-4-yloxy)-5-methoxybenzoate (143 mg) and lithium hydroxide (78 mg) were suspended in a mixed solvent composed of ethanol (10 ml) and water (1 ml), and the suspension was stirred at room temperature overnight. Next, the solvent was removed from the reaction mixture by distillation under the reduced pressure. Water was added to the residue, and the mixture was neutralized with 12 N hydrochloric acid. The mixture was then extracted with chloroform. The chloroform layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed from the extract by distillation under the reduced pressure to give the title compound (140 mg, yield 100%).

¹H-NMR (CDCl₃-d₁, 400 MHz): δ 3.73 (s, 3H), 3.80 (s, 3H), 3.95 (s, 3H), 6.44 (d, J = 5.6 Hz, 1H), 6.91 - 7.19 (m, 3H), 7.34 (s, 1H), 7.46 (s, 1H), 7.60 (s, 1H), 8.10 (d, J = 5.6 Hz, 1H), 13.26 (brs, 1H),

Mass spectrometric value (ESI-MS, m/z): 356 (M++1)

Reference Production Example 3: [2-(7-Benzyloxy-6-methoxyquinolin-4-yloxy)-5-methoxyphenyl] ethanone (intermediate r3)

[0418] 7-Benzyloxy-4-chloro-6-methoxyquinoline (3.00 mg), 5-methoxy-2-acetophenone (6.7 g), and 4-dimethylaminopyridine (4.9 g) were suspended in o-dichlorobenzene (30 ml), and the suspension was stirred at 180°C for 2 hr. The reaction mixture was cooled to room temperature. Water was added to the cooled reaction mixture, and the mixture was extracted with chloroform. The chloroform layer was washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed from the reaction mixture by distillation under the reduced pressure. The residue was purified by thin layer chromatography with an acetone-hexane system to give the title compound (2.53 g, yield 59%).

¹H-NMR (CDCl₃-d₁, 400 MHz): δ 2.42 (s, 3H), 3.82 (s, 3H), 3.98 (s, 3H), 5.26 (s, 2H), 6.28 (d, J = 5.6 Hz, 1H), 7.03 - 7.08 (m, 1H), 7.23 - 7.51 (m, 9H), 8.39 (d, J = 5.6 Hz, 1H)

Mass spectrometric value (ESI-MS, m/z): 430 (M⁺+1)

Reference Production Example 4: [2-(7-Hydroxy-6-methoxyquinolin-4-yloxy)-5-methoxyphenyl]ethanone (intermediate r4)

[0419] [2-(7-Benzyloxy-6-methoxyquinolin-4-yloxy)-5-methoxyphenyl]ethanone (intermediate r3) (2.52 g) was suspended in a mixed solvent composed of methanesulfonic acid (3.0 ml) and trifluoroacetic acid (50 ml), and the suspension was stirred at 70°C for 0.5 hr. The solvent was removed from the reaction mixture by distillation under the reduced pressure. Water was added to the residue, and the mixture was neutralized with a sodium hydrogencarbonate powder. The mixture was then extracted with chloroform. The chloroform layer was then washed with water and saturated brine and was dried over anhydrous sodium sulfate. The solvent was removed from the reaction mixture by distillation under the reduced pressure. The residue was purified by column chromatography with an acetone-hexane system to give the title compound (1.23 g, yield 62%).

¹H-NMR (DMSO-d₆, 400 MHz): δ 2.50 (s, 3H), 3.91 (s, 3H), 4.00 (s, 3H), 6.35 (d, J = 5.2 Hz, 1H), 7.34 (m, 3H), 7.42 (s, 1H), 7.61 (s, 1H), 8.44 (d, J = 5.2 Hz, 1H), 10.24 (brs, 1H),

Mass spectrometric value (ESI-MS, m/z): 338 (M⁺-1)

Production of compounds of Reference Examples

[0420] Compounds according to the present invention and compounds close thereto were produced. The relationship between the produced compounds and the schemes applied to the production of the compounds is as shown in the following table.

[0421]Table r-1:

Scheme	Compound
r2:	r1 to r5, r12, r13, r15 to r17, r19, r22, r24, r26 to r42, r57, r62 to r72, r74, r75, r77, r78, r161, r162 and r425
r3:	r9 to r11, r18, r43 to 56, r58 to 61, r73, r166, r172, r181, r188 to r192, r293, r306 to r311 and r418 to r420
r4:	r79 to r114
r5:	r118 to r160, r312 to r409 and r440 to r469
r6:	r163
r7:	r7 and r8
r8:	r6
r9:	r14
r10:	r20 and r21
r11:	r23
r12:	r76, r165, r173, r174 and r182 to r187
r13:	r115 to r117, r202, r203, r205, r206, r208 to r210, r214, r215, r217 to r221, r275 and r276

[0422]

Table r-2:

	Scheme	Compound
5	r14:	r164, r167 to r171, r294 to r296, r298 and r302
	r15:	r175 to r180
	r16:	r200 and r201
	r17:	r204, r222 and r280
	r18:	r207
10	r19:	r211, r212, r216, r223 to r255, r259, r261 to r267, r291, r434 and r438
	r20:	r213
	r21:	r256 to r258
	r22:	r277
	r23:	r278 and r279
15	r24:	r281, r282, r284 and r287 to r289
	r25:	r283, r285, r286, r290, r292, r421 to r424, r426 to r428, r436, and r439
	r26:	r297
	r27:	r299
	r28:	r300
20	r29:	r301, r303 and r304
	r30:	r305
	r31:	r410 to r414
	r32:	r415 to r417
25	r33:	r193 to r199
	r34:	r260, r268 to r274, r429 to r433, r435 and r437

Production schemes

30 **[0423]** A certain group of compounds related to the compounds according to the present invention can be produced according to the following schemes r1 to r34.

In the description of production schemes r1 to r34 in the following Reference Examples, symbols of substituents such as R1 and R2 are used. Despite the definition in the description other than Reference Examples in the present specification, the symbols of the substituents means as defined in the Reference Examples.

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Scheme r1:**[0424]**

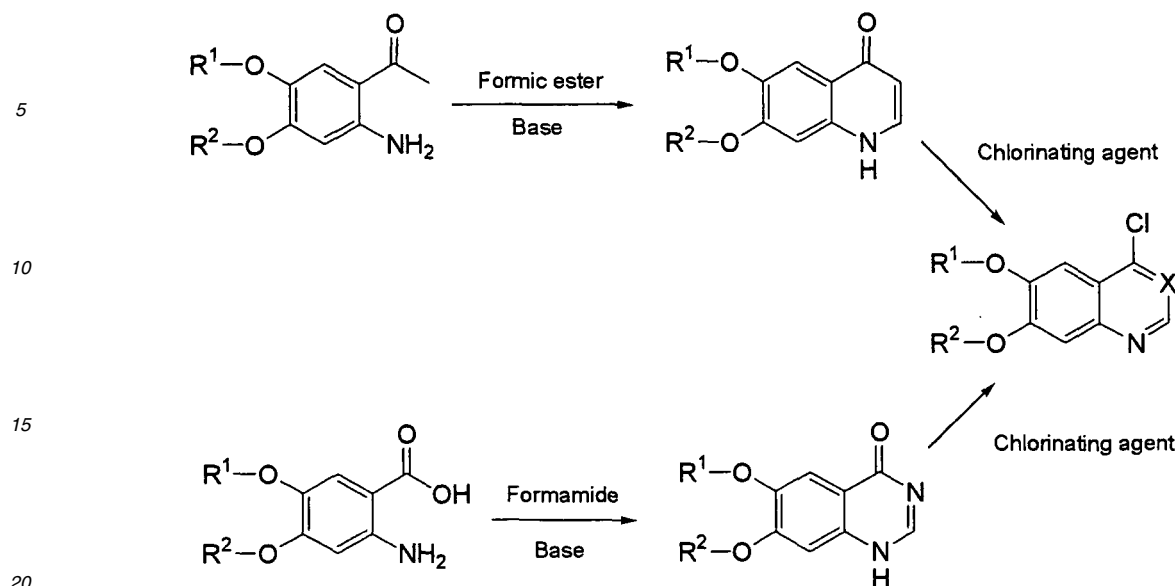
40

[Chemical formula 39]

45

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wherein X represents CH or N, and

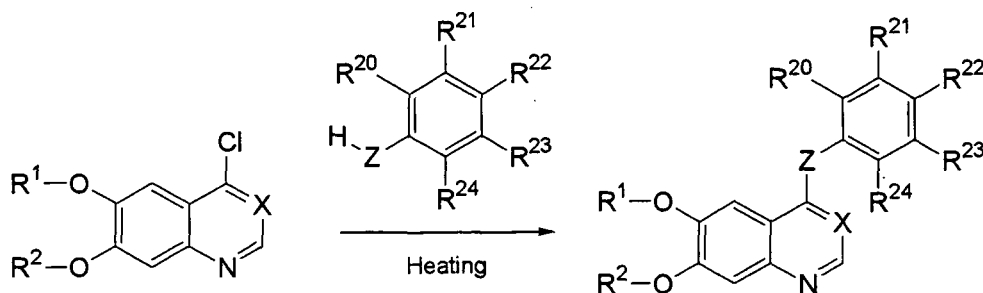
R¹ and R² independently may represent group -OR^X

wherein R^X represents a hydrogen atom or -(CH₂)_m-R^{aX}. R^{aX} represents a hydrogen atom, a halogen atom, hydroxyl, a saturated or unsaturated three- to six-membered carbocyclic or heterocyclic group, C1-4 alkoxy, C1-4 alkoxy carbonyl, or -NR^{bX}R^{cX}. R^{bX} and R^{cX}, which may be the same or different, represent a hydrogen atom or C1-6 alkyl wherein the C1-6 alkyl group is optionally substituted by hydroxyl, an oxygen atom, amino, a nitrogen atom, or C1-4 alkyl. R^{bX} and R^{cX} together may combine with the nitrogen atom to which they are attached to form a saturated or unsaturated five- or six-membered heterocyclic group. This heterocyclic group may further contain one or more heteroatoms. The heterocyclic group is optionally substituted by C1-4 alkyl optionally substituted by hydroxyl; hydroxyl; an oxygen atom; aminocarbonyl; C1-4 alkoxy; C1-4 alkoxy carbonyl; or a saturated or unsaturated five- or six-membered heterocyclic group. Further, the heterocyclic group may condense with another saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group to form a bicyclic group. m is an integer of 1 to 6. The alkyl chain part -(CH₂)_m- in the group -(CH₂)_m-R^{aX} is optionally substituted by hydroxy; an oxygen atom; -OR^{dX} wherein R^{dX} represents C1-4 alkyl or C1-4 alkyl carbonyl; or C1-4 alkyl optionally substituted by hydroxyl or a halogen atom.

Scheme r2:

[0425]

[Chemical formula 40]



wherein Z represents -O-, -NH-, -S-, or -C(=O)-, and

R²⁰ to R²⁴, which may be the same or different, represent a hydrogen atom, a halogen atom, C1-10 alkyl, C1-8 alkoxy, C2-6 alkenyl, phenylcarbonyl, amino, nitro, or a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group. R²⁰ and R²¹, or R²³ and R²⁴ together may combine with the carbon atoms to which they are attached represent

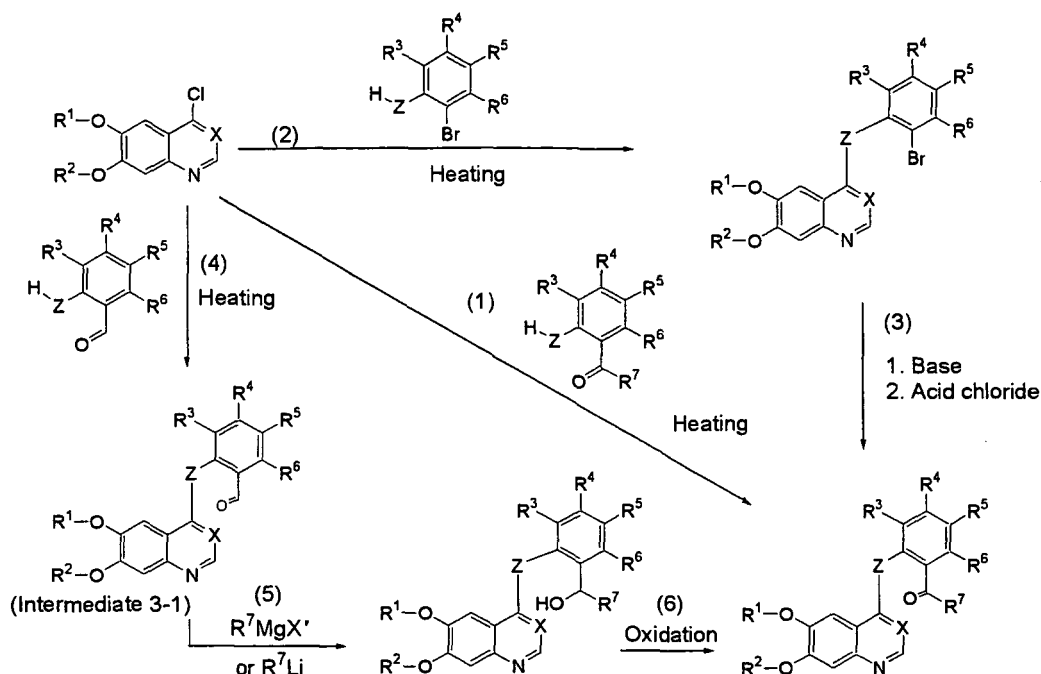
a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group. The other substituents are as defined in other production schemes in other Reference Examples.

[0426] The aimed compounds, i.e., 4-phenoxyquinoline derivatives, 4-anilinoquinoline derivatives, or corresponding quinazoline derivatives can be synthesized by reacting a phenol derivative or a corresponding aniline derivative with a 4-chloroquinoline derivative or a corresponding quinazoline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C. In scheme r1, phosphoryl chloride may be mentioned as the chlorinating agent.

Scheme r3:

[0427]

[Chemical formula 41]



wherein X' represents a halogen atom,

R³ to R⁶, which may be the same or different, represent a hydrogen atom, hydroxyl, a halogen atom, C1-6 alkyl, C1-10 alkoxy, C2-6 alkenylcarbonyloxy, C1-4 alkylcarbonyl, C1-4 alkylthio, or phenyl, and R³ and R⁴, R⁴ and R⁵, and R⁵ and R⁶ together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group,

R⁷ represents a hydrogen atom, C1-8 alkyl, C2-6 alkenyl, a saturated or an unsaturated five- or six-membered carbocyclic or heterocyclic group, group -O-R⁸, or group -N(-R⁹)R¹⁰ wherein R⁸, R⁹ and R¹⁰, and R¹¹ and R¹² represent C1-10 alkyl, C2-8 alkenyl, or a saturated or unsaturated five- or six-membered carbocyclic group or the like, and the other substituents are as defined in other production schemes in other Reference Examples.

[0428] In this scheme, the aimed compounds can be synthesized through any of the following three routes (i) to (iii).

(i) The aimed compounds can be synthesized by reacting a 4-chloroquinoline derivative or a corresponding quinazoline derivative with a phenol derivative or a corresponding aniline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (1)).

(ii) The aimed compounds can be synthesized by reacting a 4-chloroquinoline derivative or a corresponding quina-

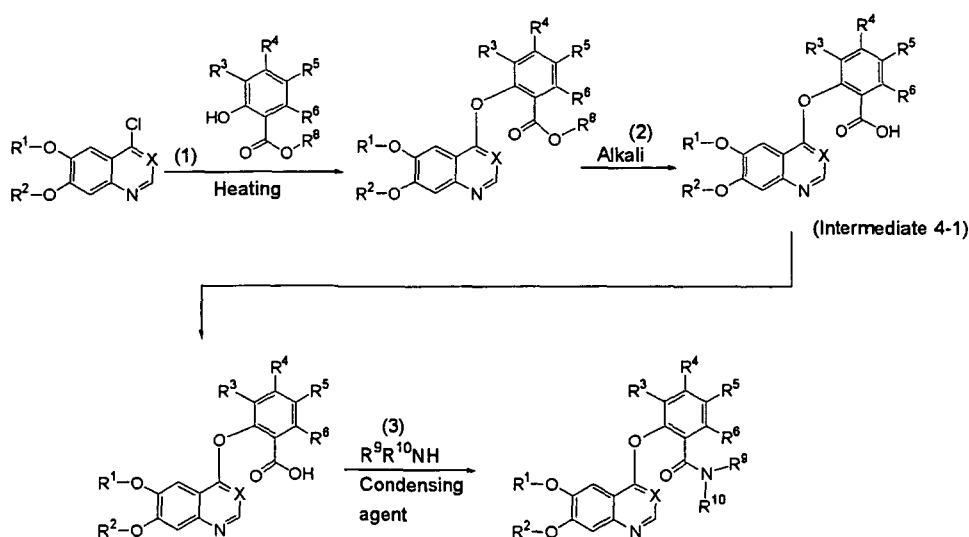
zoline derivative with an o-bromophenol derivative or a corresponding o-bromoaniline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (2)), subjecting the bromo site to dipole inversion with a metal base, for example, n-butyllithium, and reacting the resultant anion with an acid chloride (step (3)).

(iii) The aimed compounds can be produced by reacting a 4-chloroquinoline derivative or a corresponding quinazoline derivative with an o-hydroxybenzaldehyde derivative or a corresponding o-aminobenzaldehyde derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (4)), then reacting the resultant compound with an alkylating agent, for example, methylmagnesium bromide (step (5)), and oxidizing the resultant alcohol (step (6)).

Scheme r4:

[0429]

[Chemical formula 42]



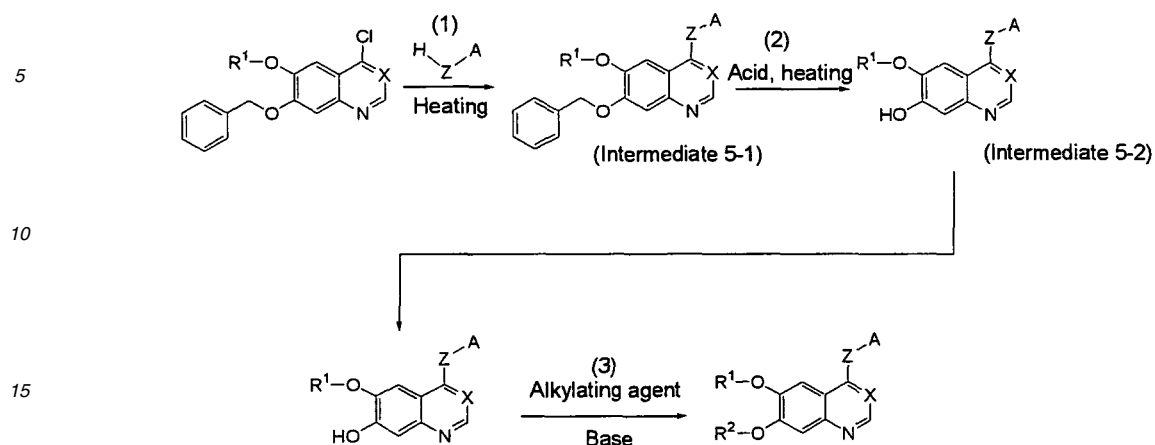
wherein the substituents are as defined above.

[0430] The aimed ester-type compounds can be produced by reacting a 4-chloroquinoline derivative or a corresponding quinazoline derivative with an o-hydroxybenzoic ester derivative or a corresponding o-aminobenzoic ester derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (1)). Next, the aimed compounds can be synthesized by hydrolyzing the ester-type compound with an alkali (step (2)) and reacting the amine with a condensing agent, for example, 1-ethyl-3-(3-dimethylaminopropyl)carbodiimide hydrochloride (step (3)).

Scheme r5:

[0431]

[Chemical formula 43]



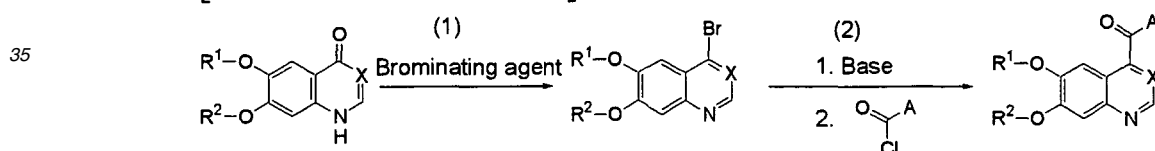
20 wherein A is as defined in the portions other than the Reference Examples in the present specification, and the other substituents are as defined above.

25 **[0432]** A 7-benzyloxy-4-chloroquinoline derivative or a corresponding quinazoline derivative is provided and is reacted with a phenol derivative or a corresponding aniline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (1)). The aimed compounds can be synthesized by deprotecting the resultant intermediate 5-1, that is, removing the benzyl group, with an acid (step (2)) and reacting the resultant intermediate 5-2 with an alkylating agent, for example, 1-bromo-2-chloroethane, in the presence of a base (step (3)).

Scheme r6:

30 **[0433]**

[Chemical formula 44]



40 wherein the substituents are as defined above.

45 **[0434]** The aimed compounds can be produced by providing a 4-quinolone derivative or a corresponding quinazolinone derivative, reacting this compound with a brominating agent, for example, phosphoryl bromide (step (1)), then subjecting the bromo site to dipole inversion with a metal base, for example, n-butyllithium, and reacting the resultant anion with an acid chloride (step (2)).

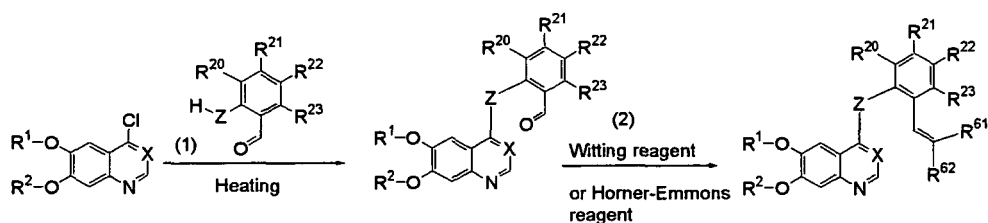
Scheme r7:

50 **[0435]**

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[Chemical formula 45]



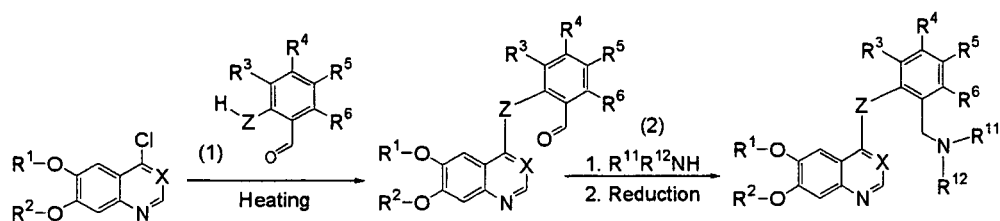
wherein R^{61} and R^{62} , which may be the same or different, represent a hydrogen atom, C1-4 alkyl, C1-4 alkoxy, C1-4 alkoxy-carbonyl, or phenyl, and the substituents are as defined above.

[0436] The aimed compounds can be synthesized by reacting a 4-chloroquinoline derivative or a corresponding quina-zoline derivative with an o-hydroxybenzaldehyde derivative or a corresponding o-aminobenzaldehyde derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (1)) and then reacting the resultant compound with a Wittig reagent or a Horner-Emmons reagent (step (2)). Phosphorus ylide may be mentioned as these reagents.

20 Scheme r8:

[0437]

[Chemical formula 46]



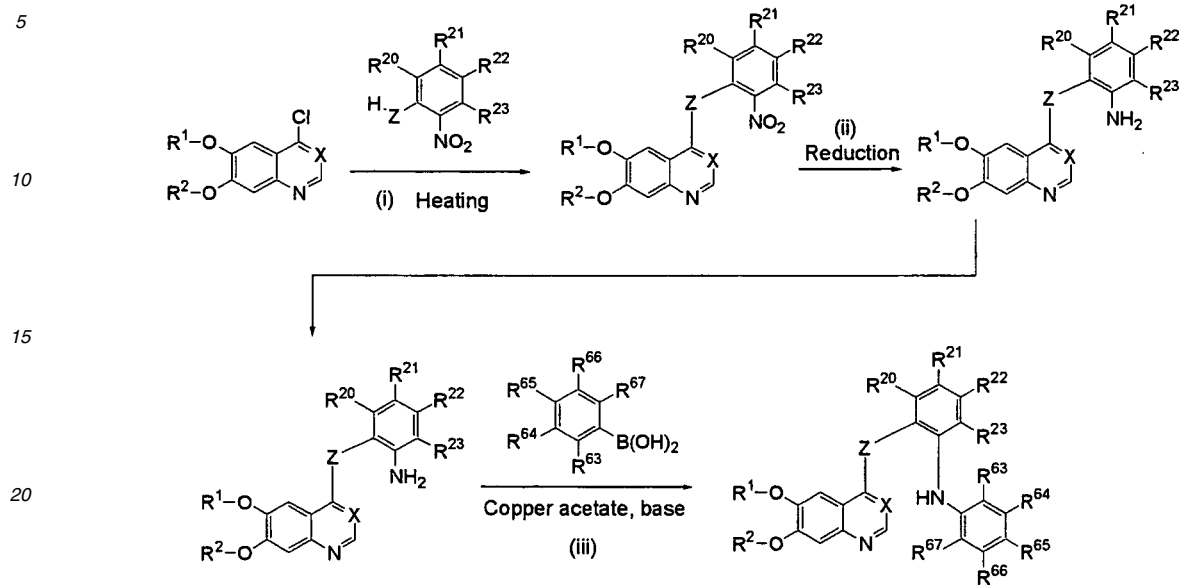
35 wherein the substituents are as defined above.

[0438] The aimed compounds can be produced by reacting a 4-chloroquinoline derivative or a corresponding quina-zoline derivative with an o-hydroxybenzaldehyde derivative or a corresponding o-aminobenzaldehyde derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (1)), then reacting the resultant compound with an amine ($R^{11}R^{12}NH$) to give an imine, and then reducing the imine (step (2)).

40 Scheme r9:

[0439]

[Chemical formula 47]



wherein R^{63} to R^{67} , which may be the same or different, represent a hydrogen atom, hydroxyl, a halogen atom, or C_{1-4} alkyl, and the other substituents are as defined above.

[0440] The aimed compounds can be synthesized by reacting a 4-chloroquinoline derivative or a corresponding quinaldine derivative with an o-nitrophenol derivative or a corresponding o-nitroaniline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)), then reducing the nitro group (step (ii)), and reacting the resultant compound with a phenylboronic acid derivative (step (iii)).

Scheme r10:

[0441]

[Chemical formula 48]

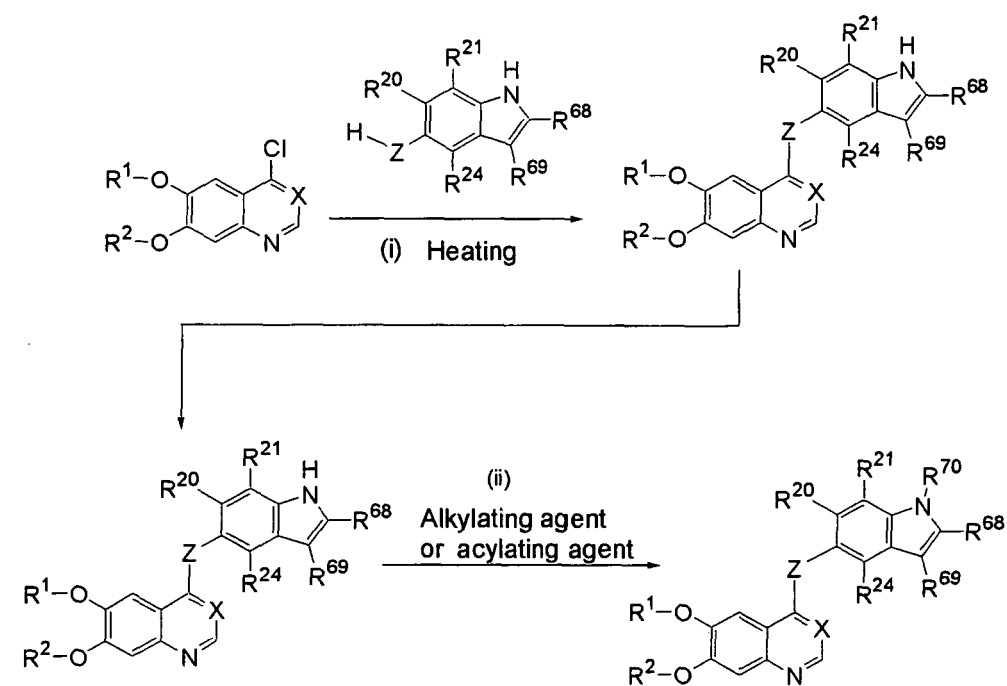
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wherein R^{68} to R^{70} , which may be the same or different, represent a hydrogen atom, a halogen atom, C_{1-2} alkylcarbonyl, C_{1-2} alkoxy carbonyl, or C_{1-4} alkyl, and the other substituents are as defined above.

30

[0442] The aimed compounds can be synthesized by reacting a 4-chloroquinoline derivative or a corresponding quinazoline derivative with a 5-hydroxyindole derivative or a corresponding 5-aminoindole derivative in a suitable solvent, for example, *o*-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)) and then alkylating the amino group with an alkylating agent, for example, methyl iodide, or acylating the amino group with an acylating agent, for example, acetyl chloride (step (ii)).

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Scheme r11:

[0443]

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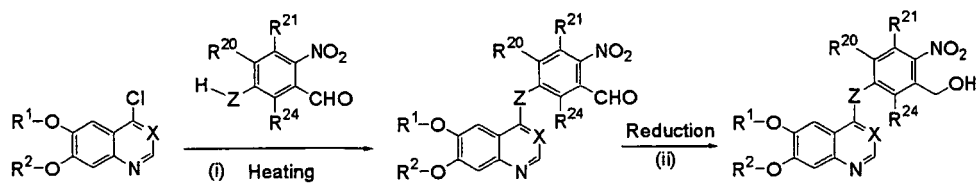
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[Chemical formula 49]

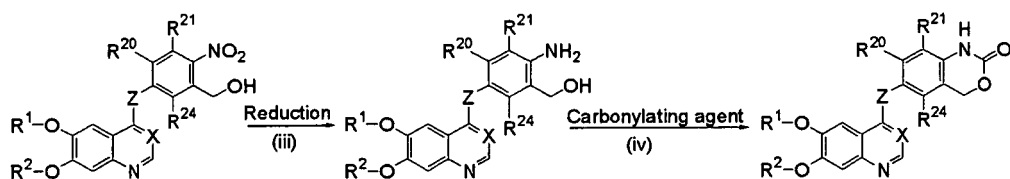
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wherein the substituents are as defined above.

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[0444] The aimed compounds can be synthesized by reacting a 4-chloroquinoline derivative or a corresponding quinazoline derivative with a 3-hydroxy-6-nitrobenzaldehyde derivative or a corresponding 5-amino-2-nitrobenzaldehyde derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent (step (i)), reducing the formyl group (step (ii)), then reducing the nitro group in the resultant compound (step (iii)), and reacting the resultant compound with a carbonylation agent, for example, triphosgene (step (iv)).

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Scheme r12:

[0445]

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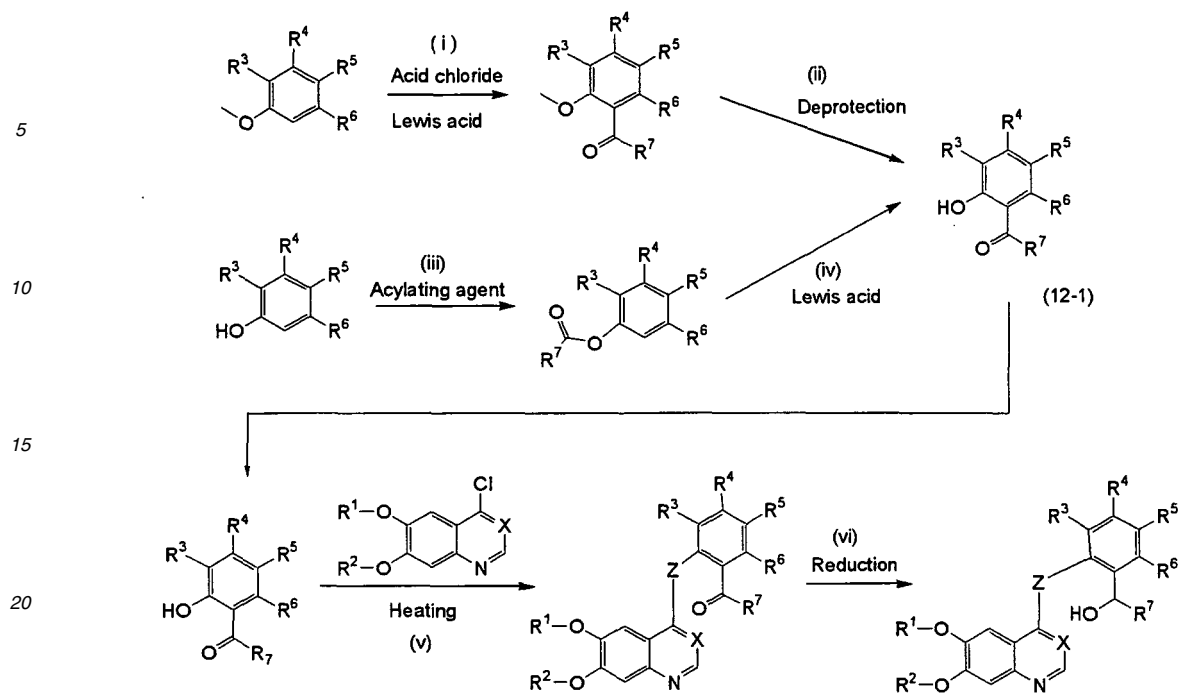
[Chemical formula 50]

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wherein the substituents are as defined above.

[0446] The compounds of formula (12-1) can be produced by reacting an anisole derivative with an acid chloride in the presence of a Lewis acid (step (i)) and deprotecting the resultant compound, that is, removing the methoxy group (step (ii)).

Alternatively, the compounds of formula (12-1) can be produced by acylating a phenol derivative, for example, acetyl chloride or acetic anhydride (step (iii)) and then reacting the resultant compound with a Lewis acid, for example, scandium trifluoromethanesulfonate (step (iv)).

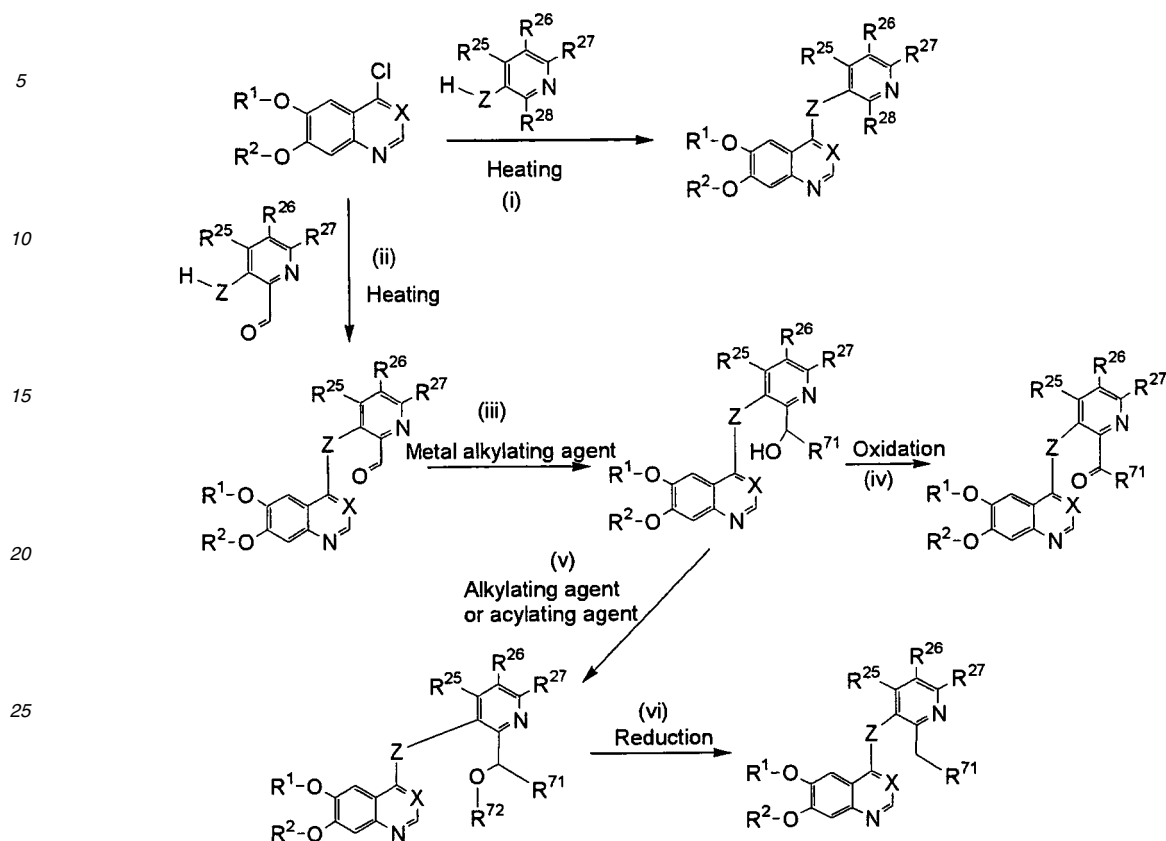
A aimed compound, for example, compound r76, can be synthesized by reacting the compound of formula (12-1) with a 4-chloroquinoline derivative or a corresponding quinazoline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (v)).

Further, a aimed compound, for example, compound r165, can be synthesized by reducing the acyl group in the resultant compound (step (vi)).

Scheme r13:

[0447]

[Chemical formula 51]



wherein R²⁵ to R²⁷, which may be the same or different, represent a hydrogen atom, a halogen atom, C1-6 alkyl, C1-8 alkoxy, C1-4 alkylcarbonyl, C1-4 alkylthio, or phenylcarbonyl, and R²⁵ and R²⁶, and R²⁶ and R²⁷ together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group,

R²⁸ represents a hydrogen atom, a halogen atom, nitro group, cyano group, C1-6 alkyl, C1-8 alkoxy, C1-4 alkylcarbonyl, C2-6 alkenyl, C2-6 alkynyl, a saturated or unsaturated three- to eight-membered carbocyclic oxy, a saturated or unsaturated six-membered carbocyclic carbonyl or heterocyclic carbonyl, or a saturated or unsaturated three- to eight-membered carbocyclic or heterocyclic group,

R⁷¹ represents methyl, ethyl, phenyl, or 2-pyridyl,

R⁷² represents a hydrogen atom or methylcarbonyl, and

the other substituents are as defined above.

[0448] The aimed compounds can be synthesized by reacting a 4-chloroquinoline derivative or a corresponding quinazoline derivative with a 3-hydroxypyridine derivative or a corresponding 3-aminopyridine derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)).

Alternatively, a 4-chloroquinoline derivative or a corresponding quinazoline derivative is reacted with a 3-hydroxy-2-pyridine carbaldehyde derivative or a corresponding 3-amino-2-pyridine carbaldehyde derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (ii)), and the resultant compound is then reacted with an alkylating agent, for example, methylmagnesium bromide (step (iii)).

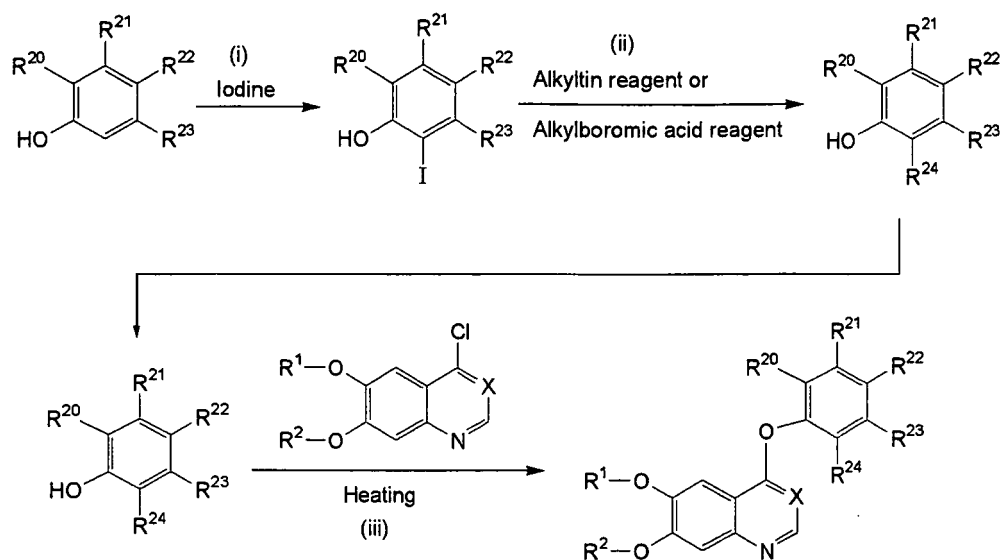
A aimed compound, for example, compound r117, can be then synthesized by oxidizing the resultant alcoholic compound, for example, with manganese dioxide as an oxidizing agent (step (iv)).

Alternatively, another aimed compound, for example, compound r218, can be synthesized by alkylating the hydroxyl group in the resultant alcoholic compound with an alkylating agent, for example, methyl iodide or ethyl iodide, or by acylating the hydroxyl group in the resultant alcoholic compound with an acylating agent, for example, acetyl chloride or acetic anhydride (step (v)). A further aimed compound, for example, compound r214, can be synthesized by reducing this compound, for example, with a hydrogen gas/palladium hydroxide as a reducing agent (step (vi)).

Scheme r14:

[0449]

[Chemical formula 52]



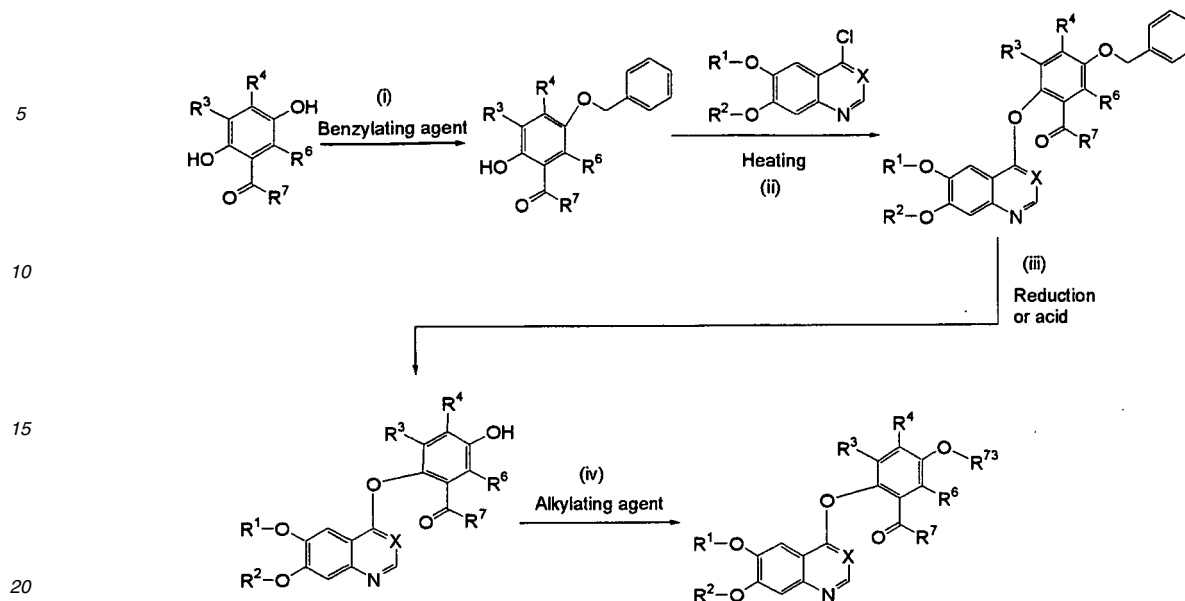
wherein the substituents are as defined above.

[0450] The aimed compounds can be produced by reacting a phenol derivative with iodine (step (i)), reacting the aryl iodide with an alkytin reagent, for example, tri-*n*-butyl-(2-pyridyl)-tin, or an alkyboronic acid reagent, for example, 3-pyridylboronic acid, in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenyl)phosphine palladium (step (ii)), and reacting the phenol derivative thus obtained with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, *o*-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (iii)).

Scheme r15:

[0451]

[Chemical formula 53]



wherein R^{73} represents a hydrogen atom, or C_{1-4} alkyl optionally substituted by phenyl, and the other substituents are as defined above.

25 **[0452]** The aimed compounds can be produced by reacting a 2,5-dihydroxyphenyl ketone derivative with a benzylating agent, for example, benzyl bromide (step (i)), reacting the monophenol derivative thus obtained with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (ii)), deprotecting the resultant compound, that is, removing the benzyl group in the resultant compound, with a suitable acid, for example, methanesulfonic acid/trifluoroacetic acid, or

30 by reducing agent (step (iii)), and then alkylating the phenolic hydroxyl in the resultant compound with an alkylating agent, for example, ethyl iodide (step (iv)).

Scheme r16:

35 **[0453]**

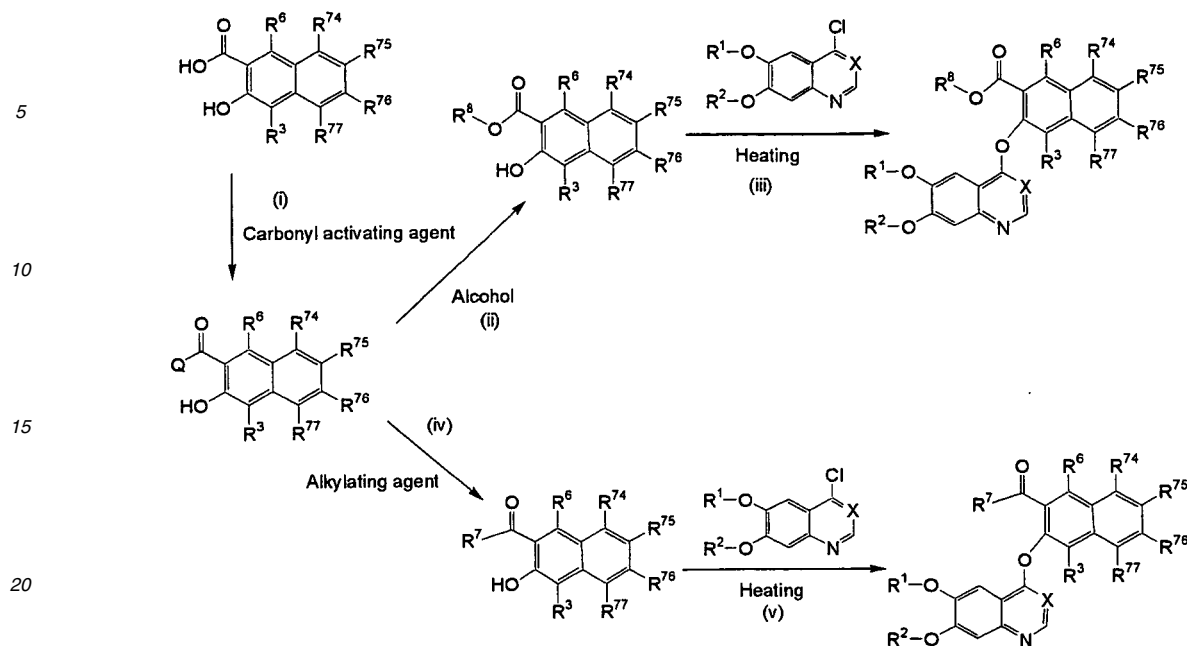
[Chemical formula 54]

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25 wherein R^{74} to R^{77} represent a hydrogen atom, a halogen atom, hydroxyl, or C_{1-4} alkyl, Q represents, for example, chlorine or N,O-dimethylhydroxylamine, and the other substituents are as defined above.

[0454] In this scheme, the aimed compounds can be synthesized through the following two routes.

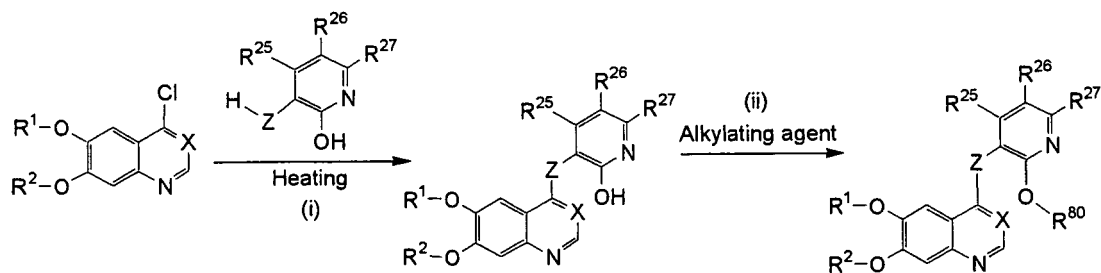
30 (I) The contemplated compound can be produced by reacting a hydroxynaphthalenecarboxylic acid derivative with a suitable carbonyl activating agent, for example, thionyl chloride (step (i)), then reacting the active carboxylic acid derivative thus obtained with an alcohol (step (ii)) to give an ester derivative, then reacting the ester derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (iii)).

35 (II) The aimed compounds can be produced by reacting the active carboxylic acid derivative produced in step (i) with an alkylating agent, for example, methylmagnesium bromide (step (iv)) to give a ketone derivative and then reacting the ketone derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (v)).

40 Scheme r17:

[0455]

45 [Chemical formula 55]



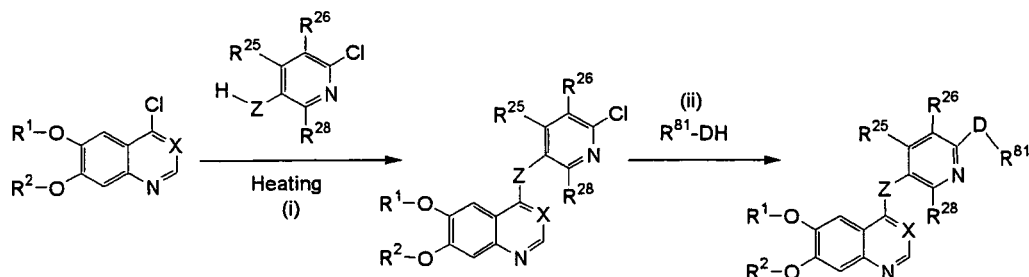
wherein R^{80} represents cyclopentyl, cyclohexyl, or phenyl, and the other substituents are as defined above.

[0456] The aimed compounds can be produced by reacting a 2-hydroxypyridine derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)) and then alkylating the resultant compound with an alkylating agent, for example, ethyl iodide (step (ii)).

Scheme r18:

[0457]

[Chemical formula 56]



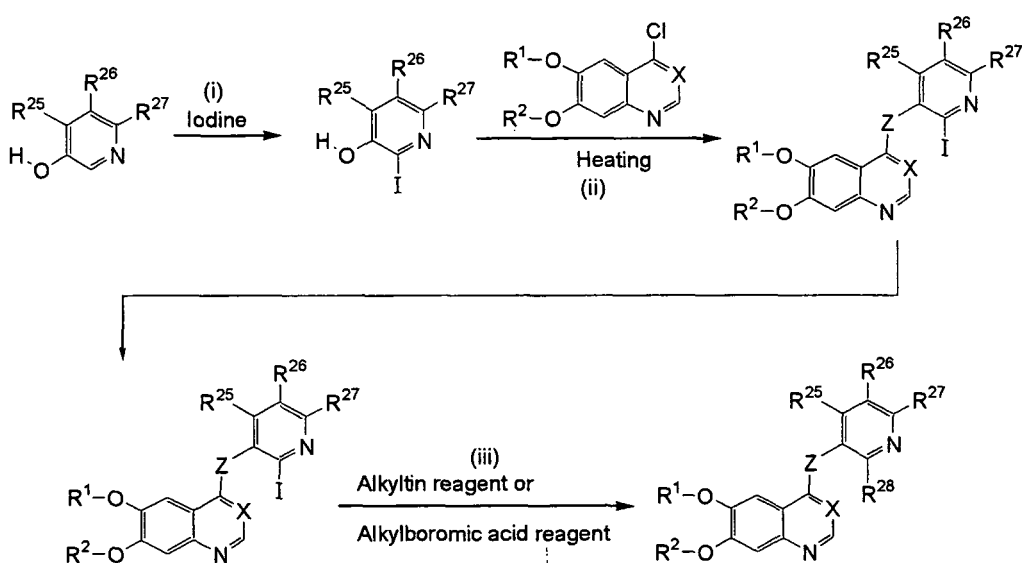
wherein R⁸¹ represents a hydrogen atom or C₁₋₄ alkyl, D represents an oxygen atom, a nitrogen atom, or a sulfur atom, and the other substituents are as defined above.

[0458] The aimed compounds can be produced by reacting a 2-chloropyridine derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)) and reacting the resultant compound with a nucleophilic reagent, for example, methanol (step (ii)).

Scheme r19:

[0459]

[Chemical formula 57]



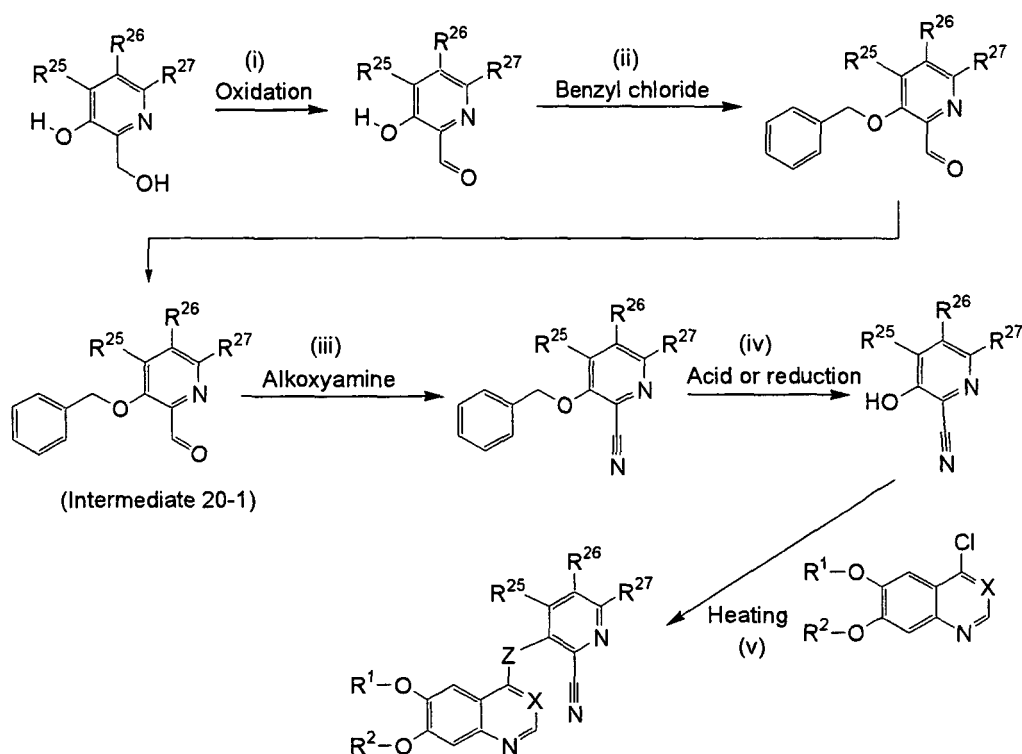
wherein the substituents are as defined above.

[0460] The aimed compounds can be produced by reacting a 3-hydroxypyridine derivative with iodine in a suitable solvent, for example, methanol (step (i)), reacting the 2-iodopyridine derivative thus obtained with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (ii)), then reacting the resultant compound with an alkyltin reagent, for example, tri-n-butyl-(2-pyridyl)-tin, or an alkylboronic acid reagent, for example, 3-pyridylboronic acid, in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenylphosphine) palladium (step (iii)).

Scheme r20:

[0461]

[Chemical formula 58]



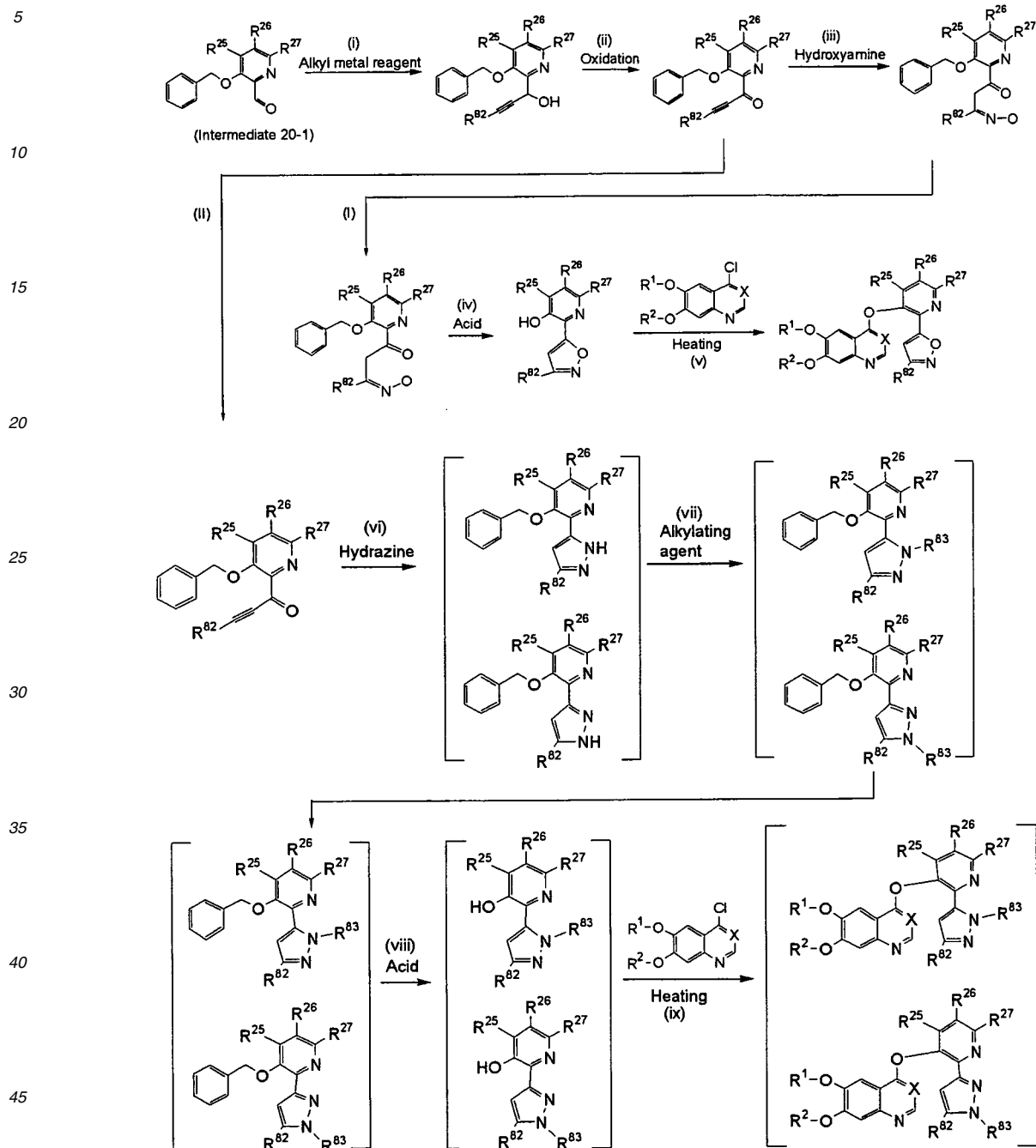
wherein the substituents are as defined above.

[0462] Intermediate 20-1 can be produced by reacting the above starting compound with a suitable oxidizing agent, for example, manganese dioxide (step (i)) and then reacting the remaining hydroxy group in the resultant compound with a suitable benzylating agent, for example, benzyl chloride (step (ii)). Next, a corresponding cyanopyridine derivative can be produced by reacting intermediate 20-1 with an alkoxyamine (step (iii)). The aimed compounds can be produced by deprotecting the cyanopyridine derivative thus obtained with a suitable acid, for example, methanesulfonic acid/trifluoroacetic acid, or a suitable reducing agent, for example, a hydrogen gas/palladium hydroxide (step (iv)), and then reacting the resultant hydroxypyridine derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (v)).

Scheme r21:

[0463]

[Chemical formula 59]



50 wherein R^{82} and R^{83} represent hydroxyl; cyano; a halogen atom; C1-4 alkoxy; phenyloxy; C1-4 alkylcarbonyl; amino optionally substituted by C1-4 alkyl or C1-4 alkylcarbonyl; aminocarbonyl optionally substituted by C1-4 alkyl; or C1-4 alkyl optionally substituted by hydroxyl or a halogen atom, and the other substituents are as defined above.

[0464] In this scheme, the aimed compounds can be synthesized through the following two routes.

55 (I) The aimed compounds can be produced by reacting intermediate 20-1 produced according to scheme r20 with an alkyne metal reagent, for example, 1-propynylmagnesium bromide (step (i)), then oxidizing the hydroxyl group in the resultant compound with a suitable oxidizing agent, for example, a benzyl group (step (ii)) to give a ketone

derivative, reacting the ketone derivative with hydroxyamine (step (iii)), reacting the resultant compound with a suitable acid, for example, methanesulfonic acid/trifluoroacetic acid (step (iv)) to give a 3-hydroxy-2-isoxazolpyridine derivative, and then reacting the 3-hydroxy-2-isoxazolpyridine derivative thus obtained with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (v)).

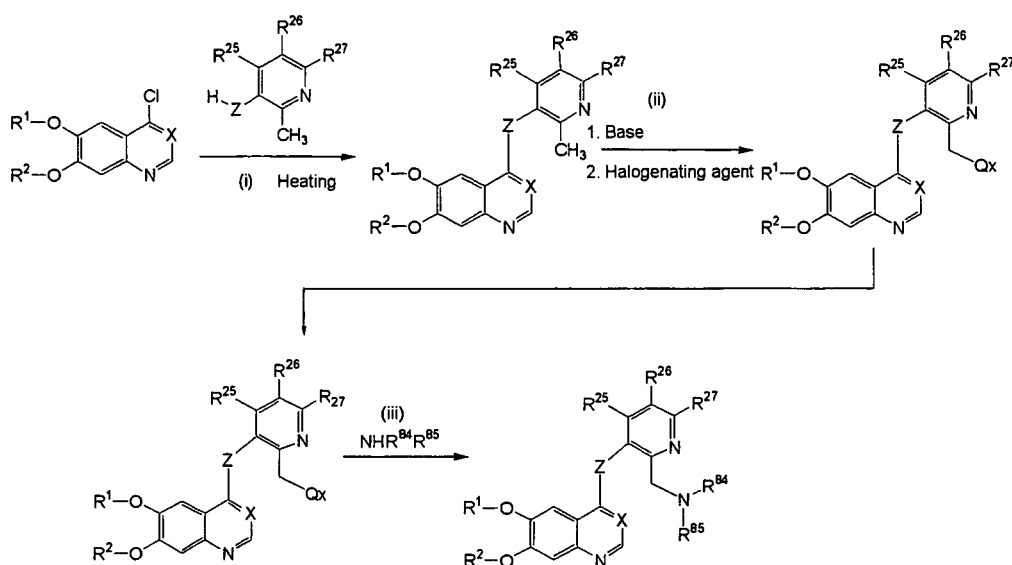
[0465]

(II) The aimed compounds can be produced by reacting intermediate 20-1 produced according to scheme r20 with an alkyne metal reagent, for example, 1-propynylmagnesium bromide (step (i)), then oxidizing the hydroxyl group in the resultant compound with a suitable oxidizing agent, for example, a benzyl group (step (ii)) to give a ketone derivative, reacting the ketone derivative with hydrazine (step (vi)), reacting the resultant compound with an alkylating agent, for example, methyl iodide (step (vii)) to give an N-alkylpyrazole derivative, reacting the N-alkylpyrazole derivative with a suitable acid, for example, methanesulfonic acid/trifluoroacetic acid (step (viii)) to give a 3-hydroxypyridine derivative, and then reacting the 3-hydroxypyridine derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (ix)).

Scheme r22:

[0466]

[Chemical formula 60]



wherein Qx represents a halogen atom, preferably a chlorine atom or a bromine atom, and the other substituents are as defined above.

[0467] The aimed compounds can be produced by reacting a 3-hydroxy-2-methylpyridine derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)) to give a quinoline derivative, allowing a suitable base, for example, lithium diisopropylamide, to act on the resultant compound to produce carbanion, reacting the carbanion with a halogenating agent, for example, N-bromosuccinimide (step (ii)), and then reacting the resultant compound with an amine (step (iii)).

Scheme r23:

[0468]

[Chemical formula 61]

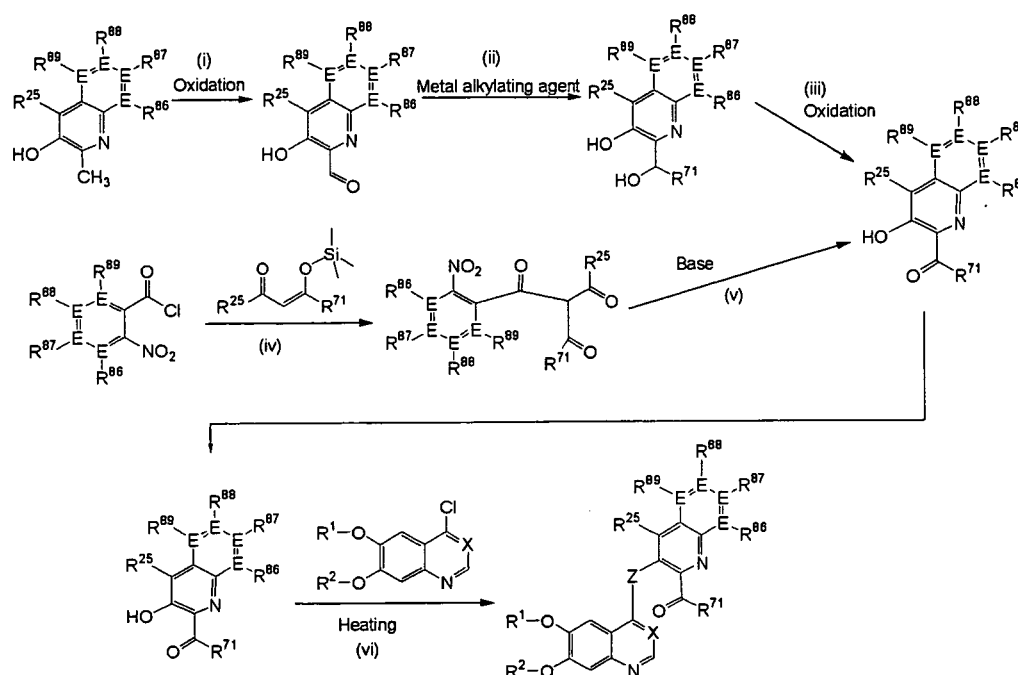
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wherein at least one of E's represents a heteroatom such as a nitrogen atom while the other E's represent a carbon atom, or all of E's represent a carbon atom, R⁸⁶ to R⁸⁹ represent a hydrogen atom, a halogen atom, or C₁₋₄ alkyl, and the other substituents are as defined above.

[0469] In this scheme, the aimed compounds can be synthesized through the following two routes.

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(I) The aimed compounds can be produced by reacting a 3-hydroxy-2-methylquinoline derivative with a suitable oxidizing agent, for example, selenium dioxide (step (i)), reacting the aldehyde derivative with a metal alkylating agent, for example, methylmagnesium bromide (step (ii)), then oxidizing the resultant alcoholic compound with a suitable oxidizing agent, for example, manganese dioxide (step (iii)) to give a ketone derivative, and reacting the ketone derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (vi)).

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[0470]

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(II) The aimed compounds can be produced by reacting an acid chloride derivative with silyl enol ether, for example, 4-trimethylsilylanlyoxy-penta-3-en-2-one (step (iv)), reacting the ketone derivative thus obtained with a suitable base, for example, an aqueous potassium hydroxide solution (step (v)) to give a 3-hydroxyquinoline derivative, and reacting the resultant 3-hydroxyquinoline derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (vi)).

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Scheme r24:

[0471]

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[Chemical formula 62]

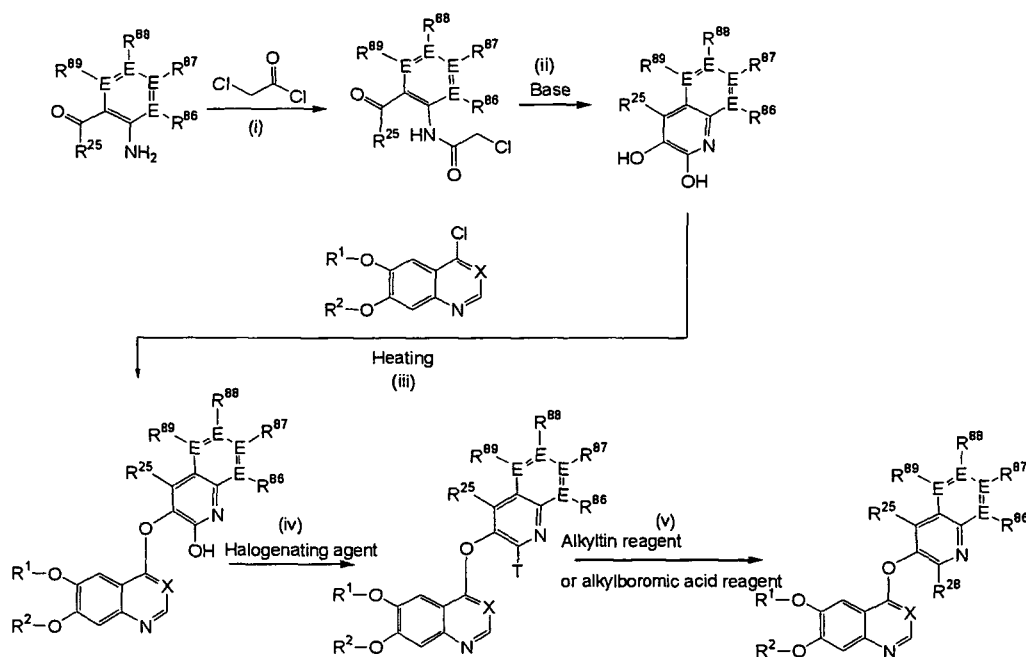
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wherein at least one of E's represents a heteroatom such as a nitrogen atom while the other E's represent a carbon atom, or all of E's represent a carbon atom,

30 T represents a halogen atom, preferably a bromine atom, and the other substituents are as defined above.

[0472] The aimed compounds can be produced by reacting an aniline derivative with chloroacetyl chloride (step (i)), then reacting the resultant amide derivative with a suitable base, for example, an aqueous potassium hydroxide solution (step (ii)) to give a 2,3-dihydroxyquinoline derivative, reacting the 2,3-dihydroxyquinoline derivative thus obtained with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180 °C (step (iii)) to give a 2-hydroxyquinoline derivative, reacting the 2-hydroxyquinoline derivative with a suitable halogenating agent, for example, tetrabutylammonium bromide (step (iv)) to give a 2-haloquinoline derivative, and reacting the 2-haloquinoline derivative with an alkyltin reagent, for example, tri-n-butyl-(2-pyridyl)-tin, or an alkylboronic acid reagent, for example, 3-pyridylboronic acid in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenyl)phosphine palladium (step (v)).

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Scheme r25:

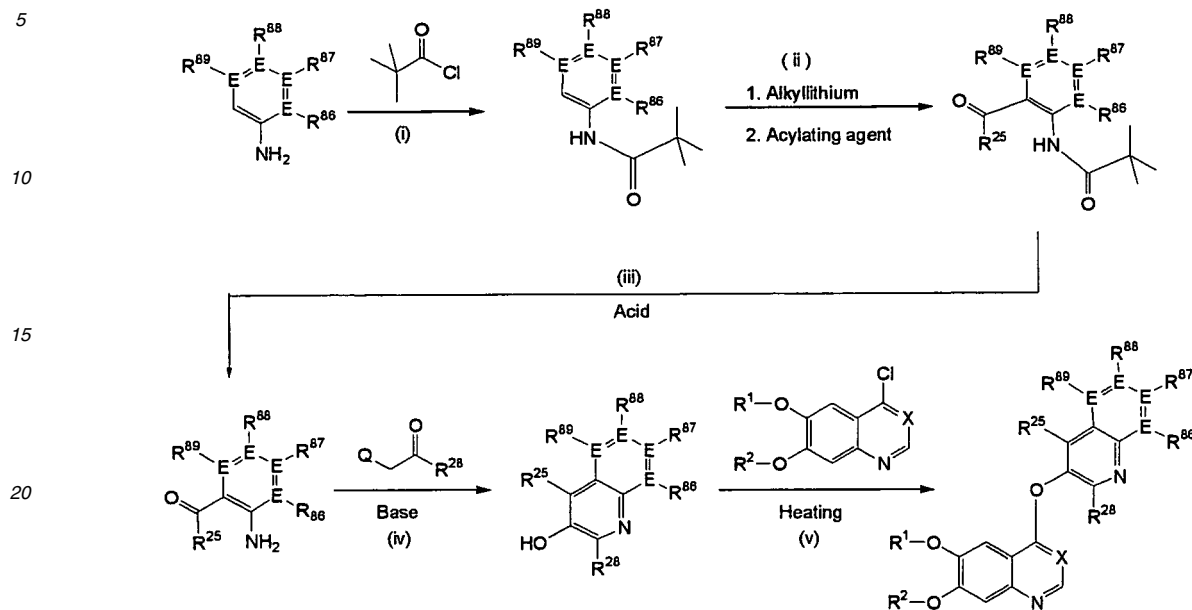
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[0473]

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[Chemical formula 63]



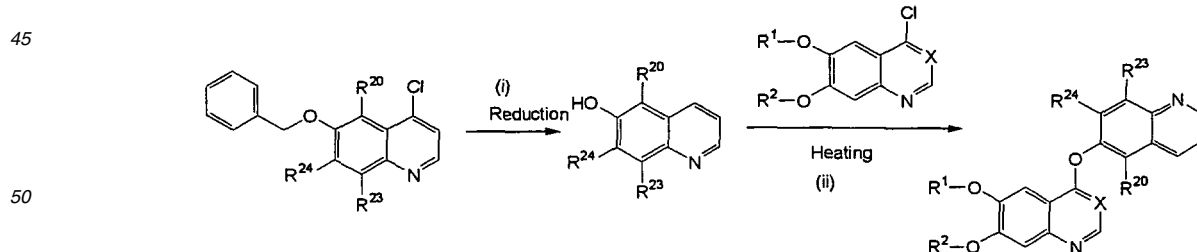
wherein at least one of E's represents a heteroatom such as a nitrogen atom while the other E's represent a carbon atom, or all of E's represent a carbon atom, and the other substituents in the scheme are as defined above.

[0474] The aimed compounds can be produced by reacting an aniline derivative with pivaloyl chloride (step (i)) to give an amide derivative, then reacting the amide derivative thus obtained with a suitable alkyl lithium, for example, n-butyllithium, reacting the resultant anion with an acylating agent, for example, N,N-dimethylformamide (step (ii)), removing the pivaloyl group with a suitable acid, for example, hydrochloric acid (step (iii)) to give an o-acylaniline derivative, reacting the resultant o-acylaniline derivative with a methyl ketone derivative (step (iv)), and then reacting the resultant 3-hydroxyquinoline derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (v)).

Scheme r26:

[0475]

[Chemical formula 64]



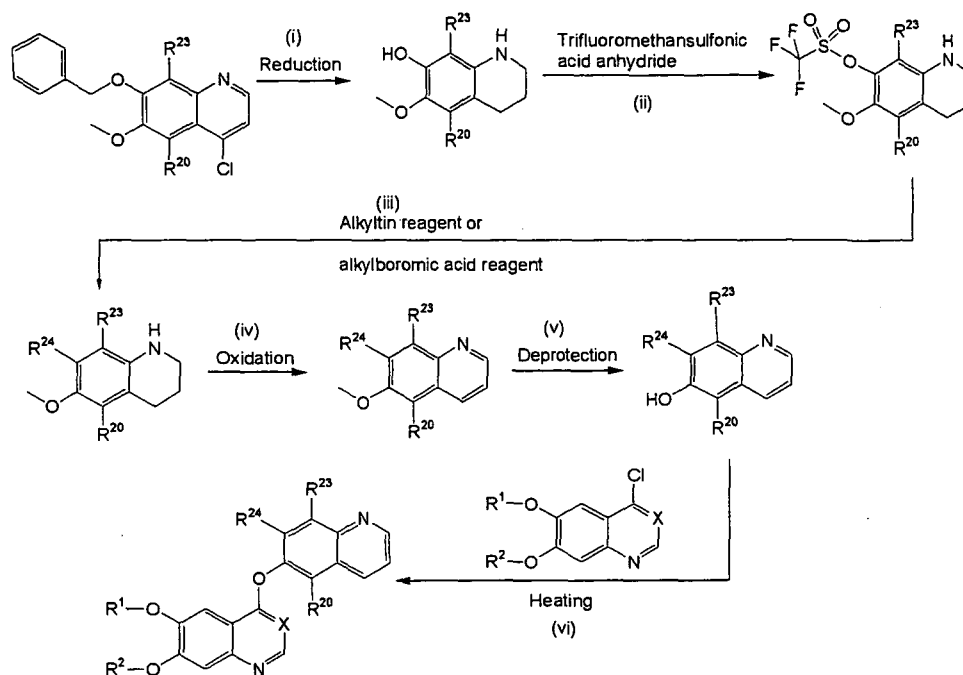
wherein the substituents are as defined above.

[0476] The aimed compounds can be produced by reacting a 6-benzyloxy-4-chloroquinoline derivative with a suitable reducing agent, for example, a hydrogen gas/palladium hydroxide) (step (i)), reacting the 6-hydroxyquinoline derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (ii)).

Scheme r27:

[0477]

[Chemical formula 65]



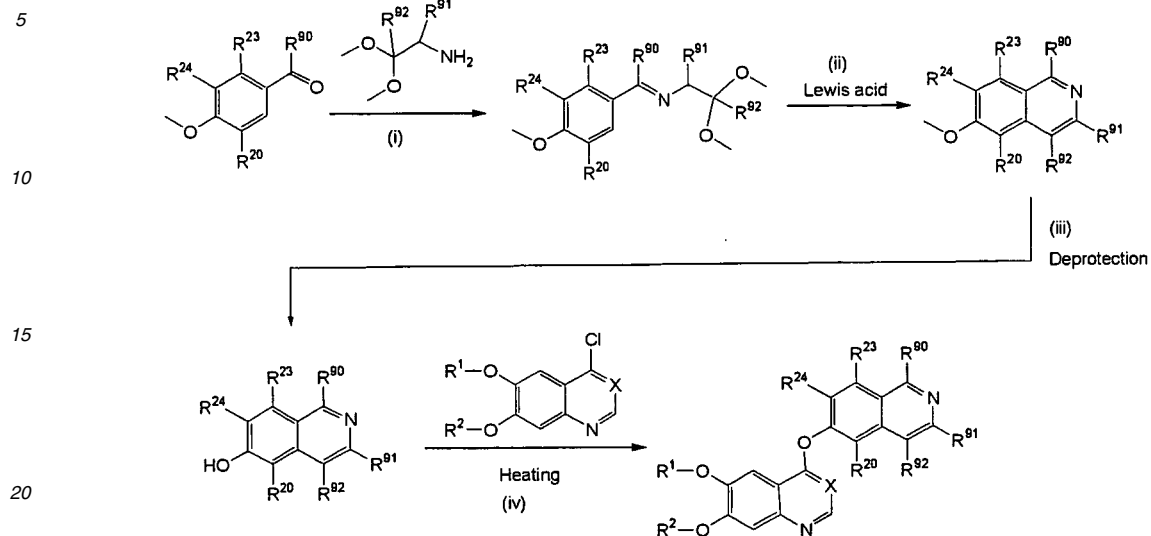
wherein the substituents are as defined above.

[0478] The aimed compounds are produced by reacting a 7-benzyloxy-4-chloroquinoline derivative with a suitable reducing agent, for example, a hydrogen gas/palladium hydroxide (step (i)), then reacting the resultant alcohol with trifluoromethanesulfonic acid anhydride (step (ii)) to give a trifluoromethanesulfonate derivative, reacting the trifluoromethanesulfonate derivative with an alkylnitrogen reagent, for example, tri-*n*-butyl-(2-pyridyl)-tin, or an alkylboronic acid reagent, for example, 3-pyridylboronic acid in the presence of a suitable transition metal catalyst, for example, tetrakis-triphenylphosphine palladium (step (iii)), and reacting the resultant compound with a suitable oxidizing agent, for example, 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (step (iv)) to give a quinoline derivative, then reacting the quinoline derivative thus obtained with a suitable reagent, for example, boron tribromide (step (v)) to give 6-hydroxyquinoline derivative, reacting the 6-hydroxyquinoline derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, *o*-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (vi)).

Scheme r28:

[0479]

[Chemical formula 66]



25 wherein R^{90} to R^{92} , which may be the same or different, represent a hydrogen atom, a halogen atom, C1-2 alkylcarbonyl, C1-2 alkoxy carbonyl, or C1-4 alkyl, and the other substituents are as defined above.

30 **[0480]** The aimed compounds can be produced by reacting a 4-methoxybenzaldehyde derivative with a dimethoxyalkylamine derivative (step (i)), reacting the resultant imine derivative with a suitable Lewis acid, for example, titanium tetrachloride (step (ii)) to give a 6-methoxyisoquinoline derivative, reacting the 6-methoxyisoquinoline derivative with a suitable reagent, for example, boron tribromide (step (iii)) to give a 6-hydroxyisoquinoline derivative, then reacting the 6-hydroxyisoquinoline derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, *o*-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (iv)).

Scheme r29:

35 **[0481]**

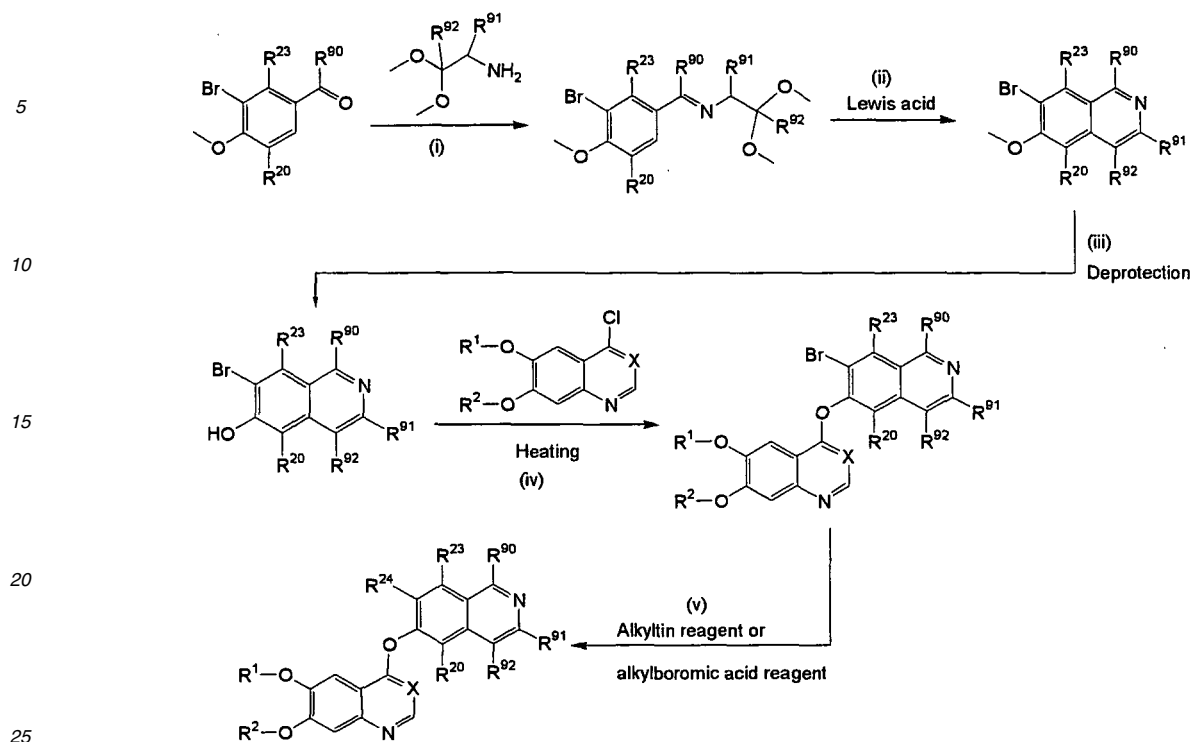
[Chemical formula 67]

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wherein the substituents are as defined above.

30 The aimed compounds can be produced by reacting a 3-bromo-4-methoxybenzaldehyde derivative with a dimethoxy-alkylamine derivative (step (i)), then reacting the resultant imine derivative with a suitable Lewis acid, for example, titanium tetrachloride (step (ii)) to give a 6-methoxyisoquinoline derivative, reacting the 6-methoxyisoquinoline derivative with a suitable reagent, for example, boron tribromide (step (iii)) to give a 6-hydroxyisoquinoline derivative, then reacting the 6-hydroxyquinoline derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (iv)) and reacting the resultant compound with an alkytin reagent, for example, tri-n-butyl-(2-pyridyl)-tin, or an alkyboronic acid reagent, for example, 3-pyridylboronic acid, in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenylphosphine) palladium (step (v)).

40 Scheme r30:

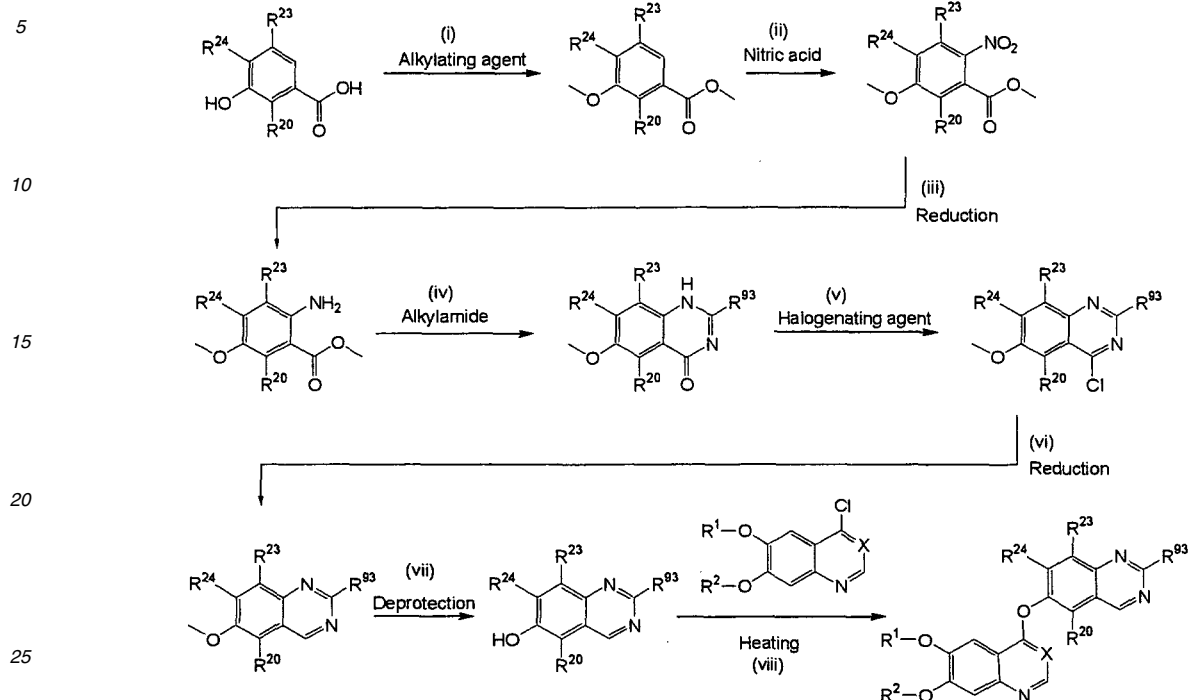
[0482]

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[Chemical formula 68]



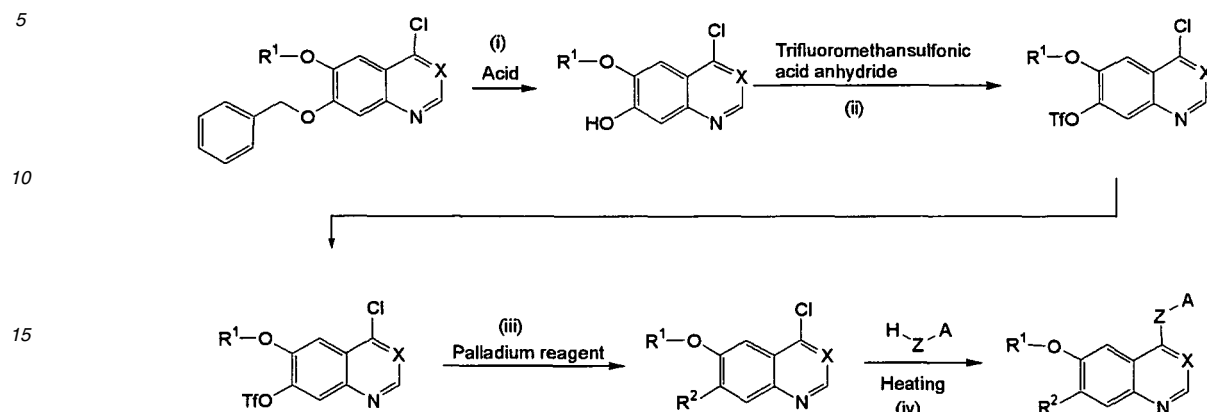
wherein R^{93} represents a hydrogen atom, a halogen atom, C1-2 alkylcarbonyl, C1-2 alkoxy carbonyl, or C1-4 alkyl, and the other substituents are as defined above.

[0483] The aimed compounds can be produced by reacting a 3-hydroxybenzoic acid derivative with an alkylating agent, for example, methyl iodide (step (i)) to give an alkyl 3-alkoxybenzoate derivative, reacting the alkyl 3-alkoxybenzoate derivative with nitric acid in the presence of a suitable acid, for example, acetic acid (step (ii)), then reducing the resultant nitro group with a suitable reducing agent, for example, a hydrogen gas/palladium hydroxide (step (iii)) to give an aniline derivative, reacting the amino group in the aniline derivative with an alkyl amide (step (iv)), then reacting the resultant compound with a suitable halogenating agent, for example, phosphorus oxychloride (step (v)) to give a 4-chloroquinazolinone derivative, then reducing the 4-chloroquinazolinone derivative with a suitable reducing agent, for example, a hydrogen gas/palladium hydroxide (step (vi)), then reacting the resultant compound with a suitable reagent, for example, boron tribromide (step (vii)) to give a 6-hydroxyquinazolinone derivative, and reacting the 6-hydroxyquinazolinone derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, *o*-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (viii)).

Scheme r31:

[0484]

[Chemical formula 69]



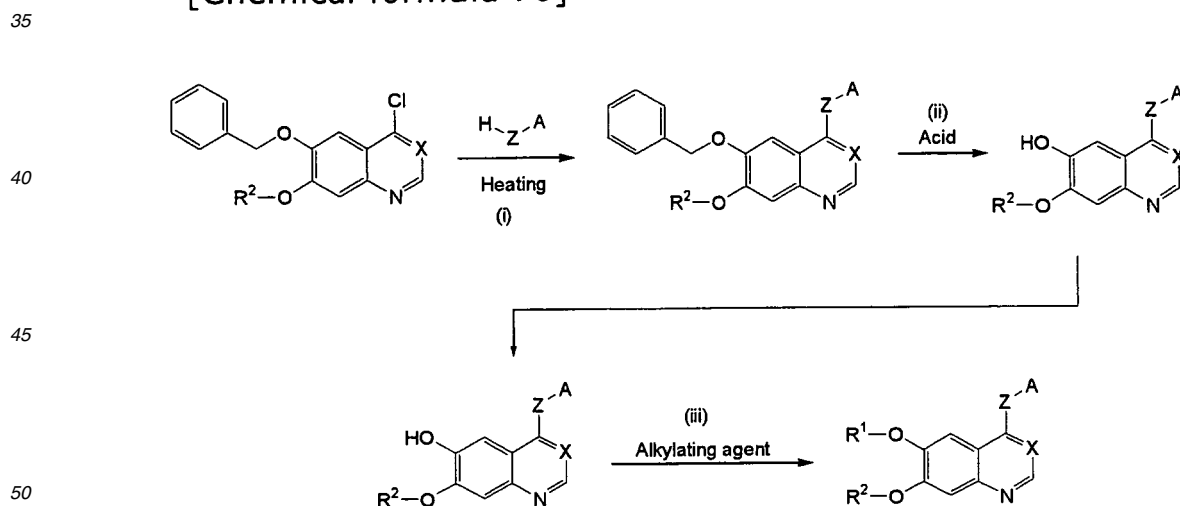
20 wherein the substituents are as defined above.

25 **[0485]** The aimed compounds can be produced by reacting a 7-benzyloxy-4-chloroquinoline derivative or a corresponding quinazolone derivative with a suitable acid, for example, methanesulfonic acid/trifluoroacetic acid (step (i)), then reacting the resultant alcohol with trifluoromethanesulfonic acid anhydride (step (ii)) to give a trifluoromethanesulfonate derivative, reacting the trifluoromethanesulfonate derivative with an amine or an alkene in the presence of a suitable transition metal catalyst, for example, tetrakis(triphenylphosphine) palladium (step (iii)), and reacting the resultant compound with a phenol derivative or a corresponding aniline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (iv)).

30 Scheme r32:

[0486]

[Chemical formula 70]



55 wherein the substituents are as defined above.

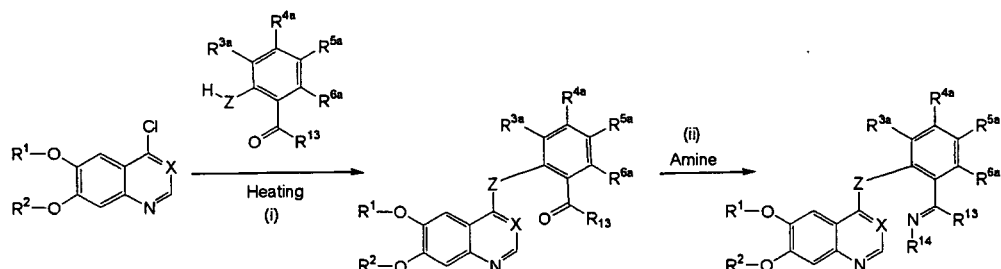
The aimed compounds can be produced by reacting a 6-benzyloxy-4-chloroquinoline derivative or a corresponding quinazolone derivative with a phenol derivative or a corresponding aniline derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)), then reacting the resultant compound with a suitable acid, for example, methanesulfonic acid/trifluoroacetic acid (step (ii)) to give 6-hydroxyquinoline

derivative, and reacting the 6-hydroxyquinoline derivative with an alkylating agent, for example, 1-bromo-2-chloroethane (step (iii)).

Scheme r33:

[0487]

[Chemical formula 71]



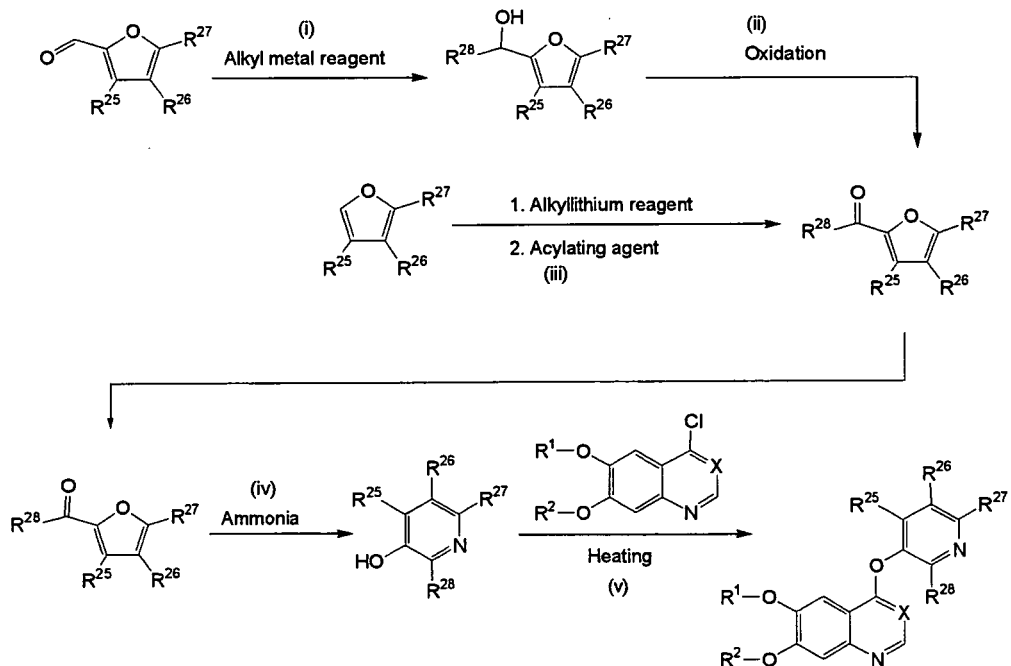
wherein R^{3a} to R^{6a} , which may be the same or different, represent a hydrogen atom, a halogen atom, or C1-6 alkyl, and the other substituents are as defined above.

[0488] The aimed compounds can be produced by reacting a 4-chloroquinoline derivative or a corresponding quinaldine derivative with a phenol derivative or a corresponding aniline derivative in a suitable solvent, for example, *o*-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (i)) and then reacting the resultant compound with an amine derivative (step (ii)).

Scheme r34:

[0489]

[Chemical formula 72]



wherein the substituents are as defined above.

[0490] In this scheme, the aimed compounds can be synthesized through the following two routes.

(I) The aimed compounds can be produced by reacting a furfural derivative with an alkyl metal reagent, for example, phenylmagnesium bromide (step (i)) to give an alcohol derivative, oxidizing the alcohol derivative with a suitable oxidizing agent, for example, manganese dioxide (step (ii)) to give a ketone derivative, then reacting the ketone derivative with ammonia (step (iv)) to give a 3-hydroxypyridine derivative, reacting the 3-hydroxypyridine derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (v)).

[0491]

(II) The aimed compounds can be produced by reacting a furan derivative with an alkyllithium reagent, for example, n-butyllithium, then reacting the resultant compound with an acylating agent, for example, benzoyl chloride (step (iii)) to give a ketone derivative, reacting the ketone derivative with ammonia (step (iv)) to give a 3-hydroxypyridine derivative, then reacting the 3-hydroxypyridine derivative with a 4-chloroquinoline derivative or a corresponding quinazolone derivative in a suitable solvent, for example, o-dichlorobenzene, or in the absence of a solvent, for example, at 120 to 180°C (step (v)).

Compound r1 to r469

[0492] Compounds r1 to r469 as Reference Examples can be produced according to schemes r1 to r34 as described above. These compounds can also be produced with reference to WO 2004/018430. For typical examples of these compounds, the names of the compounds and the measured data on the actually produced compounds will be summarized below.

Compound r1: 4-(2-Benzylphenoxy)-6,7-dimethoxyquinoline

[0493] ¹H-NMR (CDCl₃, 400 MHz): δ 3.90 (s, 2H), 3.96 (s, 3H), 4.05 (s, 3H), 6.31 (d, J = 5.4 Hz, 1H), 7.07 - 7.37 (m, 9H), 7.40 (s, 1H), 7.44 (s, 1H), 8.42 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 372 (M+1)⁺

Compound r6: 6,7-Dimethoxy-4-[4-methyl-2-(piperidinomethyl)phenoxy]quinoline

[0494] ¹H-NMR (CDCl₃, 400 MHz): δ 1.25-1.49 (m, 6H), 2.30-2.38 (m, 4H), 2.40 (s, 3H), 3.39 (s, 2H), 4.06 (s, 6H), 6.30 (d, J = 5.4 Hz, 1H), 7.01 (d, J = 8.1 Hz, 1H), 7.14 (dd, J = 1.7 Hz, 8.0 Hz, 1H), 7.39 (d, J = 1.4 Hz, 1H), 7.44 (s, 1H), 7.61 (s, 1H), 8.44 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 393 (M+1)⁺

Compound r7: 6,7-Dimethoxy-4-{4-methoxy-2-[(E)-2-phenyl-1-ethenyl]phenoxy}quinoline

[0495] ¹H-NMR (CDCl₃, 400 MHz): δ 3.85 (s, 3H), 4.00 (s, 3H), 4.01 (s, 3H), 6.29 (d, J = 5.4 Hz, 1H), 6.84 (dd, J = 3.2 Hz, 9.0 Hz, 1H), 7.01 (d, J = 8.8 Hz, 1H), 7.06 (d, J = 7.4 Hz, 1H), 7.11 - 7.28 (m, 7H), 7.43 (s, 1H), 7.61 (s, 1H), 8.38 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 414 (M+1)⁺

Compound r9: 1-{2-[(6,7-Dimethoxy-4-quinolyl)oxy]-5-methylphenyl}-1-propanol

[0496] ¹H-NMR (CDCl₃, 400 MHz): δ 0.92 (t, J = 7.3 Hz, 3H), 1.80 (m, 2H), 2.42 (s, 3H), 3.99 (s, 3H), 4.02 (s, 3H), 4.75 (t, J = 6.3 Hz, 1H), 6.24 (d, J = 5.4 Hz, 1H), 6.95 (d, J = 8.3 Hz, 1H), 7.14 (dd, J = 2.2 Hz, 8.0 Hz, 1H), 7.32 (s, 1H), 7.53 (s, 1H), 7.54 (d, J = 1.9 Hz, 1H), 8.13 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 354 (M+1)⁺

Compound r14: N-[2-[(6,7-Dimethoxy-4-quinolyl)oxy]-5-methylphenyl]-N-phenylamine

[0497] ¹H-NMR (CDCl₃, 400 MHz): δ 2.35 (s, 3H), 4.03 (s, 3H), 4.04 (s, 3H), 5.77 (s, 1H), 6.51 (d, J = 5.4 Hz, 1H), 6.76 (m, 1H), 6.96 (m, 1H), 7.01 (d, J = 8.1 Hz, 1H), 7.05 (m, 2H), 7.23 - 7.27 (m, 3H), 7.43 (s, 1H), 7.54 (s, 1H), 8.46 (d, J = 5.1 Hz, 1H)

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Mass spectrometric value (ESI-MS, m/z): 387 (M+1)⁺

Compound r20: 6,7-Dimethoxy-4-[(1-methyl-5-indolyl)oxy]quinoline

5 **[0498]** ¹H-NMR (CDCl₃, 500 MHz): δ 3.86 (s, 3H), 4.06 (s, 3H), 4.08 (s, 3H), 6.39 (d, J = 5.5 Hz, 1H), 6.50 (d, J = 3.1 Hz, 1H), 7.06 (dd, J = 2.4 Hz, 8.6 Hz, 1H), 7.15 (d, J = 3.1 Hz, 1H), 7.39 (d, J = 8.5 Hz, 1H), 7.43 (s, 1H), 7.43 (d, J = 2.4 Hz, 1H), 7.6,7 (s, 1H), 8.43 (d, J = 5.5 Hz, 1H)
Mass spectrometric value (FD-MS, m/z): 334 (M⁺)

10 Compound r23: 6-[(6,7-Dimethoxy-4-quinolyl)oxy]-1,4-dihydro-2H-3,1-benzoxazin-2-one

[0499] ¹H-NMR (CDCl₃, 500 MHz): δ 4.06 (s, 3H), 4.09 (s, 3H), 5.36 (s, 2H), 6.47 (d, J = 5.1 Hz, 1H), 7.00 (s, 1H), 7.04 (d, J = 8.5 Hz, 1H), 7.14 (d, J = 8.3 Hz, 1H), 7.52 (s, 1H), 7.53 (s, 1H), 8.53 (m, 1H), 9.13 (s, 1H)
Mass spectrometric value (FD-MS, m/z): 352 (M⁺)

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Compound r76: {2-[(6,7-Dimethoxy-4-quinolyl)oxy]-4,5-dimethylphenyl}(phenyl)methanone hydrochloride

20 **[0500]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.40 (s, 3H), 2.43 (s, 3H), 3.93 (s, 3H), 4.12 (s, 3H), 6.65 (d, J = 6.6 Hz, 1H), 7.11 (s, 1H), 7.13 (s, 1H), 7.36 (dd, J = 7.6 Hz, 7.6 Hz, 2H), 7.49 (s, 1H), 7.51 (dd, J = 7.3 Hz, 7.3 Hz, 1H), 7.66 (d, J = 7.1 Hz, 2H), 8.06 (s, 1H), 8.42 (dd, J = 6.6 Hz, 6.6 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 414 (M-HCl+1)⁺

Compound r79: Methyl 3-[(6,7-Dimethoxy-4-quinolyl)oxy]naphthalene-2-carboxylate

25 **[0501]** ¹H-NMR (CDCl₃, 400 MHz): δ 3.57 (s, 3H), 4.01 (s, 6H), 6.28 (d, J = 5.4 Hz, 1H), 7.46 - 7.61 (m, 5H), 7.77 (d, J = 8.0 Hz, 1H), 7.93 (d, J = 8.0 Hz, 1H), 8.37 (d, J = 5.4 Hz, 1H), 8.59 (s, 1H)
Mass spectrometric value (ESI-MS, m/z): 390 (M+1)⁺

Compound r115: 4-[(6-Methyl-3-pyridyl)oxy]-6,7-dimethoxyquinoline

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[0502] ¹H-NMR (CDCl₃, 400 MHz): δ 2.63 (s, 3H), 4.06 (s, 3H), 4.06 (s, 3H), 6.44 (d, J = 5.4 Hz, 1H), 7.26 (d, J = 8.3 Hz, 1H), 7.42 (dd, J = 2.7 Hz, 8.6 Hz, 1H), 7.44 (s, 1H), 7.54 (s, 1H), 8.46 (d, J = 2.7 Hz, 1H), 8.51 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 297 (M+1)⁺

35 Compound r117: 1-[[3-(6,7-Dimethoxy-4-quinolyl)oxy]-6-methyl-2-pyridyl]-1-ethanone

[0503] ¹H-NMR (CDCl₃, 400 MHz): δ 2.63 (s, 3H), 2.67 (s, 3H), 4.05 (s, 3H), 4.05 (s, 3H), 6.28 (d, J = 5.1 Hz, 1H), 7.40 (d, J = 8.6 Hz, 1H), 7.44 (s, 1H), 7.46 (d, J = 8.3 Hz, 1H), 7.57 (s, 1H), 8.47 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 339 (M+1)⁺

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Compound r118: 4-(2-Acetyl-4-methoxyphenoxy)-6-methoxy-7-quinolyl 4-morpholine carboxylate

45 **[0504]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.42 (s, 3H), 3.29 (m, 4H), 3.60 (m, 4H), 3.82 (s, 3H), 3.95 (s, 3H), 6.32 (d, J = 5.2 Hz, 1H), 7.02 - 7.09 (m, 2H), 7.36 (d, J = 2.8 Hz, 1H), 7.54 (s, 1H), 7.87 (s, 1H), 8.43 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 453 (M+1)⁺

Compound r163: Ethyl 2-[(6,7-dimethoxy-4-quinolyl)carbonyl]benzoate

50 **[0505]** ¹H-NMR (CDCl₃, 400 MHz): δ 1.01 (t, J = 7.1 Hz, 3H), 3.98 (q, J = 7.1 Hz, 2H), 4.07 (s, 3H), 4.07 (s, 3H), 7.07 (d, J = 4.6 Hz, 1H), 7.51 (s, 1H), 7.53 (dd, J = 1.4 Hz, 7.3 Hz, 1H), 7.64 (m, 1H), 7.66 (m, 1H), 8.02 (m, 1H), 8.33 (s, 1H), 8.69 (d, J = 4.6 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 366 (M+1)⁺

Compound r164: 4-(2-Iodo-4,5-dimethyl-phenoxy)-6,7-dimethoxy-quinoline

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[0506] ¹H-NMR (CDCl₃, 400 MHz): δ 2.25 (s, 3H), 2.28 (s, 3H), 4.05 (s, 3H), 4.07 (s, 3H), 6.32 (d, J = 5.4 Hz, 1H), 6.97 (s, 1H), 7.44 (s, 1H), 7.61 (s, 1H), 7.68 (s, 1H), 8.48 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 436 (M+1)⁺

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Compound r175: 1-[5-Benzyloxy-2-(6,7-dimethoxy-quinolin-4-yloxy)-phenyl]-ethanone

5 [0507] ¹H-NMR (CDCl₃, 400 MHz): δ 2.41 (s, 3H), 3.97 (s, 6H), 5.06 (s, 2H), 6.31 (d, J = 5.2 Hz, 1H), 7.02 (d, J = 8.8 Hz, 1H), 7.13 (dd, J = 8.8 Hz, J = 3.2 Hz, 1H), 7.25 - 7.41 (m, 6H), 7.45 (d, J = 3.2 Hz, 1H), 7.49 (s, 1H), 8.41 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 430 (M+1)⁺

Compound r178: 1-[2-(6,7-Dimethoxy-quinolin-4-yloxy)-5-ethoxy-phenyl]-ethanone

10 [0508] ¹H-NMR (CDCl₃, 400 MHz): δ 1.38 (t, J = 6.8 Hz, 3H), 2.41 (s, 3H), 3.98 (s, 6H), 4.04 (q, J = 6.8 Hz, 2H), 6.30 (d, J = 5.2 Hz, 1H), 7.00 - 7.07 (m, 2H), 7.34 (d, J = 2.8 Hz, 1H), 7.36 (s, 1H), 7.49 (s, 1H), 8.41 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 368 (M+1)⁺

Compound r193: {1-[2-(6,7-Dimethoxy-quinolin-4-yloxy)-4,5-dimethylphenyl]-ethylidene}-hydrazine

15 [0509] ¹H-NMR (CDCl₃, 400 MHz): δ 1.96 (s, 3H), 2.27 (s, 3H), 2.31 (s, 3H), 4.05 (s, 3H), 4.06 (s, 3H), 5.17 (brs, 2H), 6.38 (d, J = 5.4 Hz, 1H), 6.91 (s, 1H), 7.37 (s, 1H), 7.45 (s, 1H), 7.56 (s, 1H), 8.44 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 388 (M+Na)⁺

Compound r200: 1-[3-(6,7-Dimethoxy-quinolin-4-yloxy)-naphthalene-2-yl]-ethanone

20 [0510] ¹H-NMR (CDCl₃, 400 MHz): δ 2.60 (s, 3H), 4.05 (s, 3H), 4.06 (s, 3H), 6.46 (d, J = 5.2 Hz, 1H), 7.46 (s, 1H), 7.51 - 7.62 (m, 4H), 7.77 (d, J = 8 Hz, 1H), 7.99 (d, J = 7.6 Hz, 1H), 8.44 (s, 1H), 8.49 (d, J = 5.6 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 374 (M+1)⁺

Compound r204: 4-(2-Cyclopentyloxy-pyridin-3-yloxy)-6,7-dimethoxy-quinoline

25 [0511] ¹H-NMR (CDCl₃, 400 MHz): δ 1.23 - 1.81 (m, 8H), 4.06 (s, 3H), 4.06 (s, 3H), 5.43 (m, 1H), 6.31 (d, J = 5.1 Hz, 1H), 6.95 (dd, J = 1.1, 7.6 Hz, 1H), 7.43 (s, 1H), 7.49 (m, 1H), 7.58 (s, 1H), 8.10 (m, 1H), 8.46 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 367 (M+1)⁺

Compound r207: 6,7-Dimethoxy-4-(6-methoxy-pyridin-3-yloxy)-quinoline

30 [0512] ¹H-NMR (CDCl₃, 400 MHz): δ 3.89 (s, 3H), 3.96 (s, 3H), 3.97 (s, 3H), 6.31 (d, J = 5.2 Hz, 1H), 6.76 (d, J = 9.2 Hz, 1H), 7.31 - 7.39 (m, 2H), 7.47 (s, 1H), 8.02 (d, J = 2.8 Hz, 1H), 8.41 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 313 (M+1)⁺

Compound r211: 4-(6-Fluoro-2-iodo-pyridin-3-yloxy)-6,7-dimethoxy-quinoline

35 [0513] ¹H-NMR (CDCl₃, 400 MHz): δ 3.99 (s, 3H), 4.00 (s, 3H), 6.27 (d, J = 5.6 Hz, 1H), 6.95 (dd, J = 8.4 Hz, 3.6 Hz, 1H), 7.37 - 7.50 (m, 3H), 8.47 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 875 (2M+Na)⁺

Compound r213: 3-(6,7-Dimethoxy-quinolin-4-yloxy)-6-methyl-pyridin-2-carbonitrile

45 [0514] ¹H-NMR (CDCl₃, 400 MHz): δ 2.65 (s, 3H), 4.05 (s, 3H), 4.06 (s, 3H), 6.54 (d, J = 5.1 Hz, 1H), 7.41 (d, J = 8.8 Hz, 1H), 7.44 (d, J = 8.8 Hz, 1H), 7.46 (s, 1H), 7.46 (s, 1H), 8.59 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 344 (M+Na)⁺

Compound r223: 6,7-Dimethoxy-4-(6-methyl-2-phenyl-pyridin-3-yloxy)-quinoline

50 [0515] ¹H-NMR (CDCl₃, 400 MHz): δ 2.69 (s, 3H), 4.03 (s, 3H), 4.05 (s, 3H), 6.39 (d, J = 5.4 Hz, 1H), 7.22 - 7.59 (m, 5H), 7.65 - 7.70 (m, 2H), 7.81 - 7.84 (m, 2H), 8.42 (dd, J = 2.0, 5.6 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 373 (M+1)⁺

Compound r256: 4-[2-(1,5-Dimethyl-1H-pyrazol-3-yl)-6-methyl-pyridin-3-yloxy]-6,7-dimethoxy-quinoline

55 [0516] ¹H-NMR (CDCl₃, 400 MHz): δ 2.13 (s, 3H), 2.71 (s, 3H), 3.75 (s, 3H), 4.06 (s, 3H), 4.07 (s, 3H), 6.33 (d, J = 5.4 Hz, 1H), 6.41 (s, 1H), 7.17 (d, J = 8.3 Hz, 1H), 7.39 (d, J = 8.0 Hz, 1H), 7.44 (s, 1H), 7.65 (s, 1H), 8.42 (d, J = 5.1 Hz, 1H)

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Mass spectrometric value (ESI-MS, m/z): 413 (M+Na)⁺

Compound r260: 4-[2-(4,5-Dimethylthiazol-2-yl)-5,6-dimethyl-pyridin-3-yloxy]-6,7-dimethoxy-quinoline

5 **[0517]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.13 (s, 3H), 2.27 (s, 3H), 2.35 (s, 3H), 2.64 (s, 3H), 4.07 (s, 3H), 4.07 (s, 3H), 6.33 (d, J = 5.1 Hz, 1H), 7.33 (s, 1H), 7.45 (s, 1H), 7.71 (s, 1H), 8.42 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 444 (M+Na)⁺

Compound r277: [3-(6,7-Dimethoxy-quinolin-4-yloxy)-quinolin-2-ylmethyl]-diisopropyl-amine

10 **[0518]** ¹H-NMR (CDCl₃, 400 MHz): δ 0.91 - 0.95 (m, 12H), 3.06 (m, 2H), 4.05 (s, 3H), 4.06 (s, 3H), 4.10 (s, 2H), 6.48 (d, J = 5.4 Hz, 1H), 7.46 (s, 1H), 7.54 (m, 1H), 7.61 (s, 1H), 7.70 - 7.73 (m, 2H), 7.73 (s, 1H), 8.17 (d, J = 8.5 Hz, 1H), 8.51 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 446 (M+1)⁺

Compound r278: 1-[3-(6,7-Dimethoxy-quinolin-4-yloxy)-quinolin-2-yl]-ethanone

15 **[0519]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.70 (s, 3H), 3.99 (s, 6H), 6.30 (d, J = 5.2 Hz, 1H), 7.42 (s, 1H), 7.53 - 7.66 (m, 2H), 7.76 (m, 2H), 7.90 (s, 1H), 8.16 (d, J = 9.2 Hz, 1H), 8.41 (d, J = 5.2 Hz, 1H)
20 Mass spectrometric value (ESI-MS, m/z): 375 (M+1)⁺

Compound r281: 4-(2-Bromo-quinolin-3-yloxy)-6,7-dimethoxy-quinoline

25 **[0520]** ¹H-NMR (CDCl₃, 400 MHz): δ 4.05 (s, 6H), 6.44 (d, J = 5.2 Hz, 1H), 7.50 (s, 1H), 7.54 - 7.65 (m, 2H), 7.70 - 7.79 (m, 2H), 7.89 (s, 1H), 8.11 (d, J = 8.4 Hz, 1H), 8.51 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 411 (M+1)⁺

Compound r283: 6,7-Dimethoxy-4-(2-phenyl-quinolin-3-yloxy)-quinoline

30 **[0521]** ¹H-NMR (CDCl₃, 400 MHz): δ 4.02 (s, 3H), 4.05 (s, 3H), 6.47 (d, J = 5.1 Hz, 1H), 7.32 - 7.36 (m, 3H), 7.41 (s, 1H), 7.50 (s, 1H), 7.59 (m, 1H), 7.76 (m, 1H), 7.80 (d, J = 8.1 Hz, 1H), 7.95 - 7.98 (m, 3H), 8.24 (d, J = 8.6 Hz, 1H), 8.45 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 409 (M+1)⁺

Compound r284: {3-[3-(6,7-Dimethoxy-quinolin-4-yloxy)-quinolin-2-yl]-phenyl}-methanol

35 **[0522]** ¹H-NMR (CDCl₃, 400 MHz): δ 3.86 (s, 3H), 3.95 (s, 3H), 4.56 (s, 2H), 6.24 (d, J = 5.2 Hz, 1H), 7.16 - 7.24 (m, 3H), 7.42 (s, 1H), 7.49 (m, 1H), 7.68 (m, 2H), 7.80 (d, J = 5.2 Hz, 1H), 7.84 (s, 1H), 8.01 (s, 1H), 8.12 (m, 2H)
Mass spectrometric value (ESI-MS, m/z): 437 (M-1)⁻

Compound r297: 6,7-Dimethoxy-4-(7-methoxy-quinolin-6-yloxy)-quinoline

40 **[0523]** ¹H-NMR (CDCl₃, 400 MHz): δ 3.93 (s, 3H), 4.06 (s, 3H), 4.07 (s, 3H), 6.38 (d, J = 5.1 Hz, 1H), 7.34 (dd, J = 4.4, 8.3 Hz, 1H), 7.45 (s, 1H), 7.56 (s, 1H), 7.63 (s, 1H), 7.63 (s, 1H), 8.05 (d, J = 8.1 Hz, 1H), 8.48 (d, J = 5.1 Hz, 1H), 8.88 (dd, J = 1.4, 4.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 363 (M+1)⁺

Compound r299: 6,7-Dimethoxy-4-(7-phenyl-quinolin-6-yloxy)-quinoline

50 **[0524]** ¹H-NMR (CDCl₃, 400 MHz): δ 4.01 (s, 3H), 4.03 (s, 3H), 6.47 (d, J = 5.4 Hz, 1H), 7.23 - 7.32 (m, 3H), 7.38 (s, 1H), 7.44 - 7.47 (m, 2H), 7.61 - 7.63 (m, 3H), 8.12 (d, J = 7.8 Hz, 1H), 8.30 (s, 1H), 8.43 (d, J = 5.1 Hz, 1H), 8.97 (dd, J = 1.7, 4.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 409 (M+1)⁺

Compound r300: 6,7-Dimethoxy-4-(7-methyl-isoquinolin-6-yloxy)-quinoline

55 **[0525]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.37 (s, 3H), 3.96 (s, 3H), 3.99 (s, 3H), 6.35 (d, J = 5.2 Hz, 1H), 7.36 (s, 1H), 7.39 (s, 1H), 7.47 (m, 2H), 7.86 (s, 1H), 8.41 (d, J = 5.6 Hz, 1H), 8.44 (d, J = 5.2 Hz, 1H), 9.15 (s, 1H)

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Mass spectrometric value (ESI-MS, m/z): 347 (M+1)⁺

Compound r301: 4-(7-Bromo-isoquinolin-6-yloxy)-6,7-dimethoxy-quinoline

5 **[0526]** ¹H-NMR (CDCl₃, 400 MHz): δ 3.97 (s, 3H), 3.99 (s, 3H), 6.44 (d, J = 5.2 Hz, 1H), 7.40 (s, 1H), 7.49 (m, 3H), 8.32 (s, 1H), 8.50 (m, 2H), 9.17 (s, 1H)
Mass spectrometric value (ESI-MS, m/z): 412 (M+1)⁺

Compound r303: 6,7-Dimethoxy-4-(7-pyridin-2-yl-isoquinolin-6-yloxy)-quinoline

10 **[0527]** ¹H-NMR (CDCl₃, 400 MHz): δ 3.93 (s, 3H), 3.97 (s, 3H), 6.27 (d, J = 5.2 Hz, 1H), 7.12 (m, 1H), 7.34 (s, 1H), 7.41 (s, 1H), 7.51 (m, 3H), 7.71 (d, J = 7.6 Hz, 1H), 8.40 (d, J = 5.2 Hz, 1H), 8.49 (d, J = 6.0 Hz, 1H), 8.52 (s, 1H), 8.60 (d, J = 4.4 Hz, 1H), 9.31 (s, 1H)
Mass spectrometric value (ESI-MS, m/z): 432 (M+Na)⁺

Compound r305: 6-(6,7-Dimethoxy-quinolin-4-yloxy)-7-methyl-quinazoline

15 **[0528]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.51 (s, 3H), 4.07 (s, 3H), 4.10 (s, 3H), 6.45 (d, J = 5.4 Hz, 1H), 7.57-7.59 (m, 3H), 8.06 (s, 1H), 8.53 (d, J = 5.4 Hz, 1H), 9.31 (s, 1H), 9.34 (s, 1H)
20 Mass spectrometric value (ESI-MS, m/z): 348 (M+1)⁺

Compound r320: 1-[2-[6-Methoxy-7-(3-morpholin-4-yl-propoxy)-quinolin-4-yloxy]-4,5-dimethyl-phenyl]-ethanone hydrochloride

25 **[0529]** ¹H-NMR (CD₃OD, 400 MHz): δ 2.25 - 2.55 (m, 11H), 3.22 (m, 2H), 3.49 (m, 2H), 3.67 (d, J = 12.0 Hz, 2H), 3.86 (t, J = 12.0 Hz, 2H), 4.02 - 4.18 (m, 5H), 4.47 (m, 2H), 6.76 (d, J = 5.2 Hz, 1H), 7.22 (s, 1H), 7.52 (s, 1H), 7.84 (s, 1H), 7.92 (s, 1H), 8.60 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 465 (M+1-2HCl)⁺

Compound r351: 7-Benzyloxy-6-methoxy-4-(2-methyl-quinolin-3-yloxy)-quinoline

30 **[0530]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.66 (s, 3H), 4.07 (s, 3H), 5.35 (s, 2H), 6.37 (d, J = 5.1 Hz, 1H), 7.29 - 7.37 (m, 1H), 7.37 - 7.44 (m, 2H), 7.49 - 7.57 (m, 4H), 7.61 (s, 1H), 7.72 (ddd, J = 1.5, 6.8, 8.3 Hz, 1H), 7.75 (d, J = 8.1 Hz, 1H), 7.80 (s, 1H), 8.10 (d, J = 8.6 Hz, 1H), 8.48 (d, J = 5.1 Hz, 1H)
35 Mass spectrometric value (ESI-MS, m/z): 423 (M+1)⁺

Compound r352: 6-Methoxy-4-(2-methyl-quinolin-3-yloxy)-quinolin-7-ol

40 **[0531]** ¹H-NMR (DMSO-d₆, 400 MHz): δ 2.54 (s, 3H), 3.93 (s, 3H), 6.43 (d, J = 5.1 Hz, 1H), 7.31 (s, 1H), 7.52 - 7.62 (m, 2H), 7.73 (dd, J = 7.1, 7.1 Hz, 1H), 7.92 (d, J = 8.1 Hz, 1H), 8.00 (d, J = 8.3 Hz, 1H), 8.13 (s, 1H), 8.40 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 333 (M+1)⁺

Compound r383: 6-Methoxy-4-(2-methyl-quinolin-3-yloxy)-7-oxilanyl methoxy-quinoline

45 **[0532]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.66 (s, 3H), 2.83 - 2.89 (m, 1H), 2.94 - 3.01 (m, 1H), 3.49 - 3.57 (m, 1H), 4.06 (s, 3H), 4.21 (dd, J = 5.6, 11.2 Hz, 1H), 4.46 (dd, J = 3.4, 11.5 Hz, 1H), 6.38 (d, J = 5.4 Hz, 1H), 7.48 (s, 1H), 7.55 (dd, J = 7.8, 7.8 Hz, 1H), 7.60 (s, 1H), 7.69 - 7.80 (m, 2H), 7.82 (s, 1H), 8.10 (d, J = 8.6 Hz, 1H), 8.50 (d, J = 5.2 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 389 (M+1)⁺

Compound r384: 3-[6-Methoxy-4-(2-methyl-quinolin-3-yloxy)-quinolin-7-yloxy]-propane-1,2-diol

50 **[0533]** ¹H-NMR (CDCl₃, 400 MHz): δ 2.65 (s, 3H), 3.86 - 3.97 (m, 2H), 4.04 (s, 3H), 4.22-4.35 (m, 2H), 4.39 (dd, J = 3.9, 9.8 Hz, 1H), 6.41 (d, J = 5.4 Hz, 1H), 7.55 (dd, J = 7.6, 7.6 Hz, 1H), 7.57 (s, 1H), 7.60 (s, 1H), 7.72 (d, J = 7.1 Hz, 1H), 7.76 (d, J = 8.5 Hz, 1H), 7.83 (s, 1H), 8.11 (d, J = 8.6 Hz, 1H), 8.50 (d, J = 5.4 Hz, 1H)
55 Mass spectrometric value (ESI-MS, m/z): 407 (M+1)⁺

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Compound r410: [6-Methoxy-4-(2-methyl-quinolin-3-yloxy)-quinolin-7-yl]-(2-morpholin-4-yl-ethyl)-amine

5 [0534] ¹H-NMR (CDCl₃, 400 MHz): δ 2.53 (s, 3H), 2.68 (s, 3H), 2.76 (m, 2H), 3.38 (m, 2H), 3.76 (m, 4H), 4.04 (s, 3H), 5.41 (m, 1H), 6.28 (d, J = 5.4 Hz, 1H), 7.08 (s, 1H), 7.44 (s, 1H), 7.53 (m, 1H), 7.68 - 7.74 (m, 2H), 7.76 (s, 1H), 8.09 (d, J = 8.6 Hz, 1H), 8.42 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 445 (M+1)⁺

Compound r415: 6-Benzyloxy-7-methoxy-4-(2-methyl-quinolin-3-yloxy)-quinoline

10 [0535] ¹H-NMR (CDCl₃, 400 MHz): δ 2.61 (s, 3H), 4.06 (s, 3H), 5.32 (s, 2H), 6.41 (d, J = 5.1 Hz, 1H), 7.22 - 7.40 (m, 3H), 7.44 - 7.58 (m, 4H), 7.61 (s, 1H), 7.67 - 7.76 (m, 3H), 8.09 (d, J = 8.3 Hz, 1H), 8.51 (d, J = 5.1 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 423 (M+1)⁺

Compound r416: 6-(2-Imidazol-1-yl-ethoxy)-7-methoxy-4-(2-methyl-quinolin-3-yloxy)-quinoline

15 [0536] ¹H-NMR (CDCl₃, 400 MHz): δ 2.62 (s, 3H), 4.06 (s, 3H), 4.39 - 4.54 (m, 4H), 6.36 (d, J = 5.2 Hz, 1H), 7.08 (s, 1H), 7.15 (s, 1H), 7.48 (s, 1H), 7.50 - 7.59 (m, 2H), 7.68 - 7.78 (m, 3H), 7.79 (s, 1H), 8.10 (d, J = 8.1 Hz, 1H), 8.51 (d, J = 5.4 Hz, 1H)
Mass spectrometric value (ESI-MS, m/z): 449 (M+Na)⁺

20 Evaluation test

[0537] Test Example 1A: TGFβ signal inhibitory activity (in vitro test)

25 The compounds according to the present invention was evaluated for TGFβ signal inhibitory activity according to the method described in J. Boil .Chem., 273, 21145-21152 (1998).

Specifically, a plasmid having four tandem binding sequences of Smad3, a TGF-beta signal transducer, to the upstream of a luciferases gene were used as a reporter plasmid ((SBE)4-Luc) to detect TGF-beta signal,

This reporter gene was introduced into human pulmonary carcinoma epithelial cells (A549) (available from ATCC) to establish a stable cell line.

30 A test compound and TGFβ-1 (2 ng/ ml) were added to the cells, and the mixture was cultured for 4 hr. In this case, the compounds according to the present invention synthesized in the Examples were used as the test compound. After the culture, the luciferase activity of the cells were measured by chemiluminescence (Steady Glo (trademark) luciferase assay system, available from Promega).

Likewise, the luciferase activity was measured as a control against the culture of cells with the addition of TGFβ only and the culture of cells without the addition of both TGFβ and the test compound.

35 [0538] The TGFβ inhibition (%) was calculated by the following equation, based on the measurement results.

$$40 \text{ TGF}\beta \text{ inhibition (\%)} = (A - B)/(A - C) \times 100$$

wherein

A: luciferase activity with the addition of TGFβ1 and without the addition of test compound (relative luciferase unit),

B: luciferase activity with the addition of both TGFβ1 and test compound (relative luciferase unit), and

45 C: luciferase activity without the addition of both TGFβ1 and test compound (relative luciferase unit).

[0539] The test was carried out for each of test compound at the concentrations of 3 μM and 10 μM. For certain test compounds, the test was further carried out for test compound at the concentration of 1 μM.

The results were as shown in Table 1A.

50 The results show that the compounds according to the present invention have antagonistic activities against the action of TGFβ.

Test Example 1B: TGFβ signal inhibitory activity (in vitro test)

55 [0540] For the compounds of Reference Examples, the TGFβ signal inhibitory activity was evaluated in the same manner as in Test Example 1A.

The results were as shown in Table 1B

[0541] Table A:

[Table 1]

Compound	Name of compound	Measured molecular weight
178	2-[6-Methoxy-4-(2-phenyl-[1,8]naphthyridin-3-yl oxy)-quinolin-7-yloxy]-ethanol	462(M+ Na)+
179	4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-6-methoxy-quinoline-7-carboxylic acid amide	423(M+ Na)+
180	3-(2-Tert-butyl-thieno[3,2-b]pyridin-7-yloxy)-6-ethyl-[2,2']bipyridine	412(M+ Na)+
181	2-[4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yloxy]-ethanol	410(M+ Na)+
182	2-[4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yloxy]-ethyl acetate	452(M+ Na)+
183	3-(6-Benzoyloxy-quinolin-4-yloxy)-6-ethyl-[2,2']bipyridine	456(M+ Na)+
184	4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-ol	366(M+ Na)+
185	6-Chloro-4-(6-ethyl-[2,2']bipyridinyl-3-yloxy)-quinoline-7-carboxylic acid amide	427(M+ Na)+
186	4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-ylacetate	408(M+ Na)+
187	4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yl methanesulfonate	444(M+ Na)+
188	6,7-Dimethoxy-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline	397(M+ Na)+
189	1-[2-[4-(6-Ethyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yloxy]-ethyl]-3-propyl-urea	494(M+ Na)+
190	6-Benzoyloxy-4-(6-ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline	457(M+ Na)+
191	4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-ol	343(M-1)-
192	2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethanol	411(M+ Na)+
193	6-Benzoyloxy-4-(6-ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline-7-carboxylic acid amide	500(M+ Na)+
194	4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6-hydroxy-quinoline-7-carboxylic acid amide	386(M-1)-
200	2-[4-(5,6-Dimethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethanol	411(M +Na)+
201	4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin -6-ol	329(M -1)-
202	2-[4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethanol	397(M +Na)+
203	N-{2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethyl}-methanesulfonic acid amide	488(M +Na)+
204	2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethylamine	410(M +Na)+
205	2-[4-(6-Methyl-[2,2']bipyridinyl-3-yloxy)-quinolin-6-yloxy]-ethanol	374(M +1)+
206	2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethyl acetate	453(M +Na)+
207	2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethyl 2,2-dimethyl-propanate	495(M +Na)+
208	2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethyl (S)-2-amino-3-methyl-butanoate	510(M +Na)+

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(continued)

Compound	Name of compound	Measured molecular weight
5 209	4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6-(2-morpholin-4-yl-ethoxy)-quinoline	466(M +Na)+
210	6-(3-Chloro-propoxy)-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline	429(M +Na)+
10 211	2-(Methyl-{3-[4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-propyl}-amino)-ethanol	468(M +Na)+
212	4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6-(3-piperidin-1-yl-propoxy)-quinoline	478(M +Na)+
15 213	6-Cyclobutylmethoxy-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline	421(M +Na)+
214	6-(2,2-Dimethyl-propoxy)-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline	423(M +Na)+
20 215	2,2-Dimethyl-3-[4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-propan-1-ol	439(M +Na)+
216	6-(2-Cyclohexylethoxy)-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline	463(M +Na)+
25 217	4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline-7-carboxylic acid amide	380(M +Na)+
218	4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-6-[3-(4-pyridin-2-yl-piperazin-1-yl)-propoxy]-quinoline	556(M +Na)+
30 219	2-({3-[4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-propyl}-phenylamino)-ethanol	530(M +Na)+
220	6-[3-(4-Benzyl-piperidin-1-yl)-propoxy]-4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinoline	568(M+Na) +
35 221	2-(4-{3-[4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-propyl}-piperazin-1-yl)-ethanol	523(M +Na) +
222	3-[4-(6-Methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-propan-1-ol	411(M+Na) +
40 223	ethyl-methyl-{2-[4-(6-methyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethyl}-amine	438(M+Na) +
224	2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-quinolin-6-yloxy]-ethyl 2,2-dimethyl-butanoate	509(M +Na)+
45 225	2-[4-(6-Ethyl-2-pyrimidin-2-yl-pyridin-3-yloxy)-7-fluoro-quinolin-6-yloxy]-ethanol	429(M +Na)+

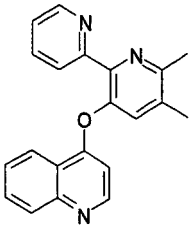
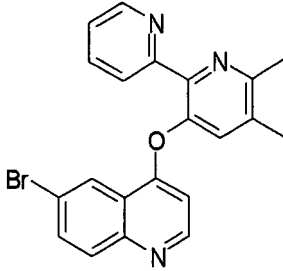
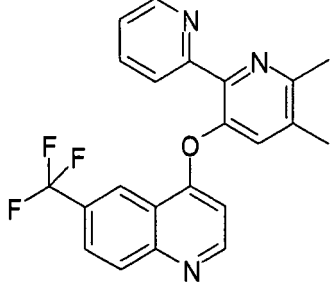
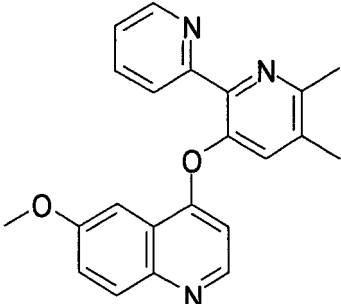
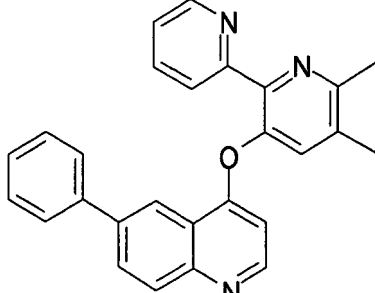
[0542] Table 1A:

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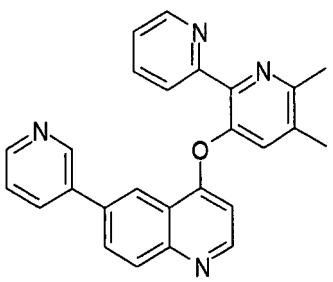
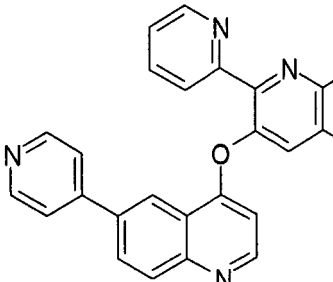
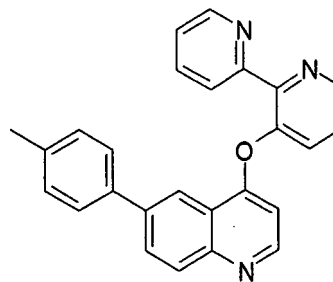
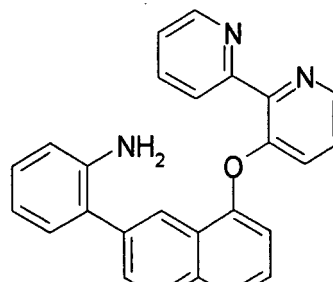
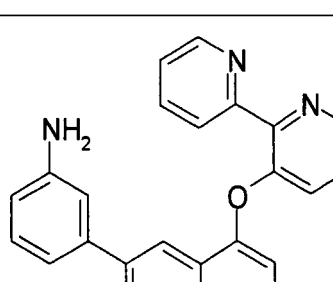
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[Table 1A]

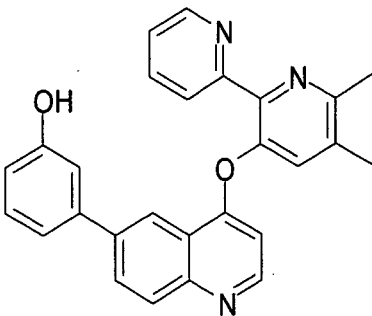
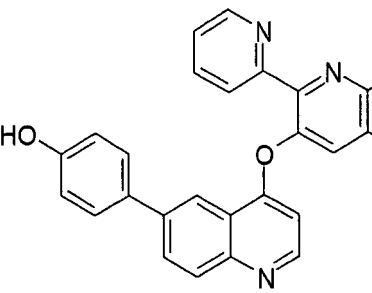
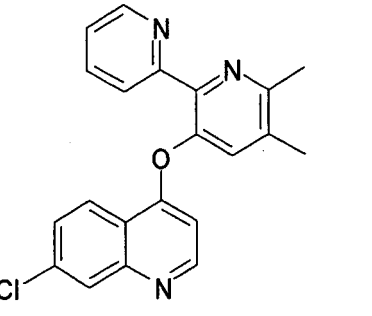
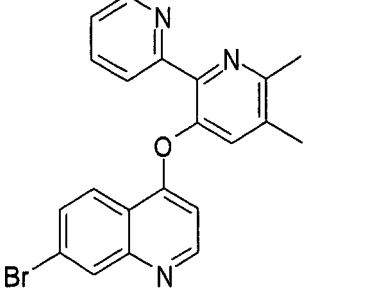
Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
1		100	100	
2		100	100	
3			99	79
4			100	94
5		100	79	

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(continued)

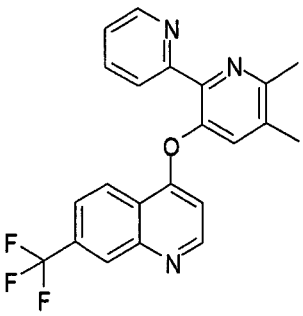
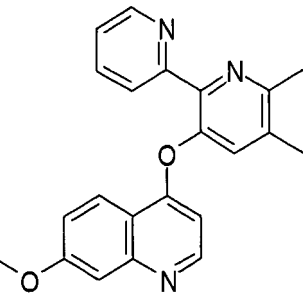
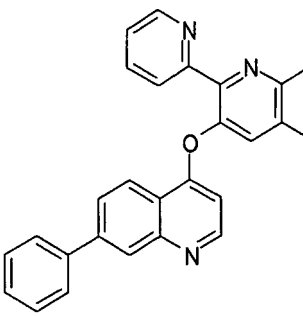
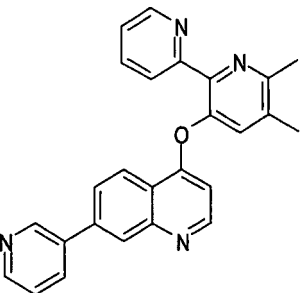
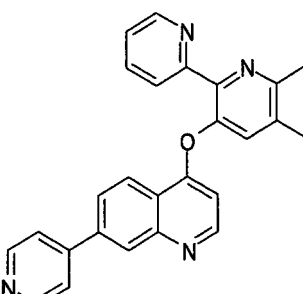
Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
6		100	100	
7		100	100	
8		100	60	
9		100	87	
10		100	100	

(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
11		100	100	
12		100	100	
13		100	99	
14		100	100	

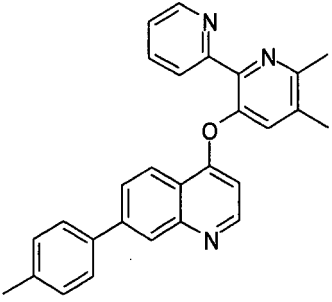
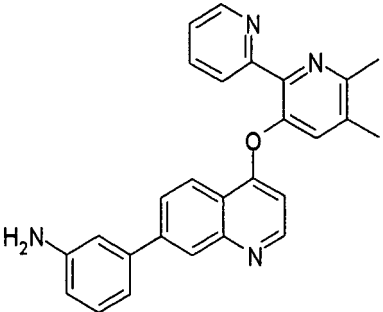
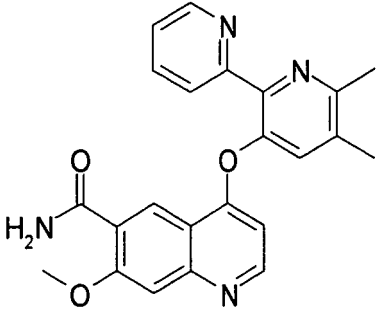
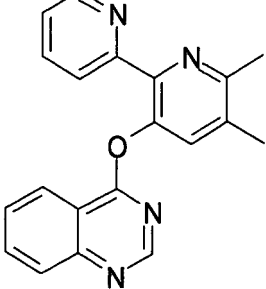
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
15		100	99	
16			100	97
17		100	98	
18		100	95	
19		100	100	

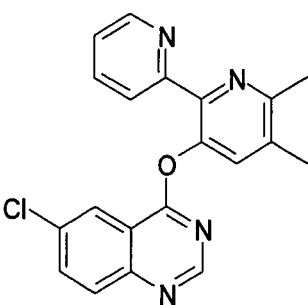
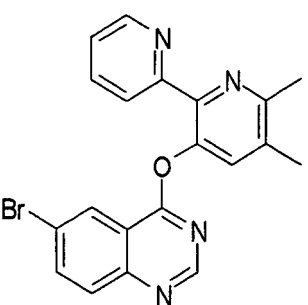
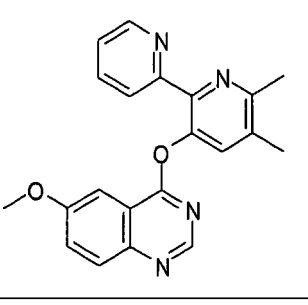
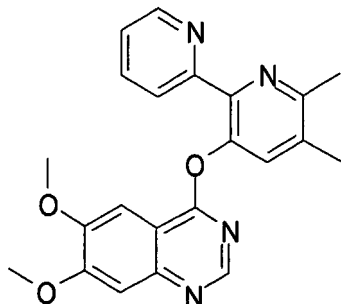
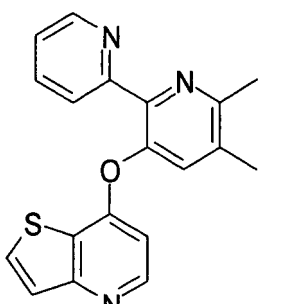
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
20		100	90	
21		100	99	
22			99	81
23		98	78	

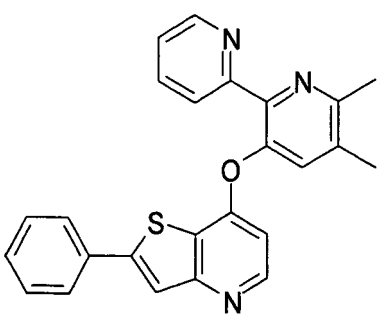
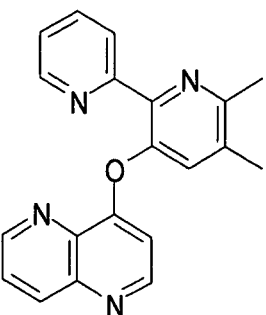
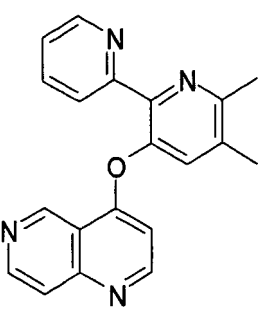
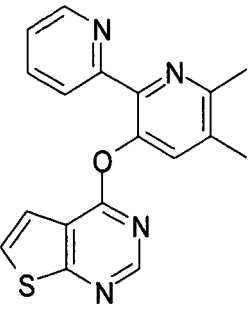
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
24		99	90	
25		99	89	
26		99	83	
27			100	89
28			100	96

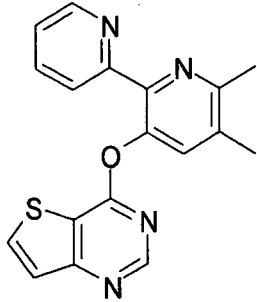
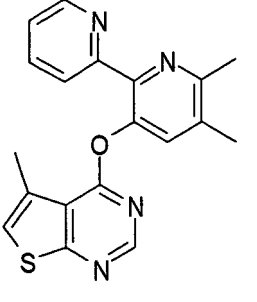
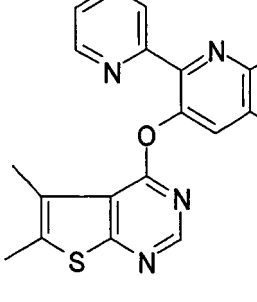
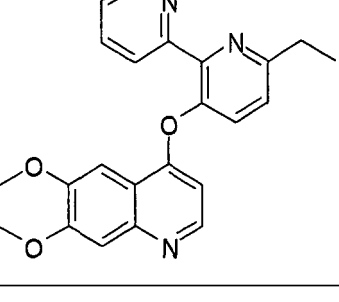
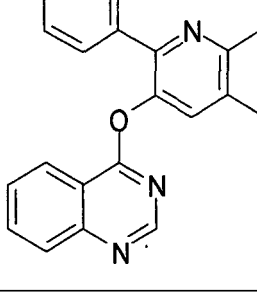
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
29			100	89
30		99	84	
31		99	85	
32		94	64	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
33		99	86	
34		100	94	
35		100	95	
37			100	98
38		89	45	

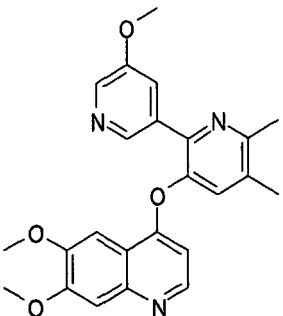
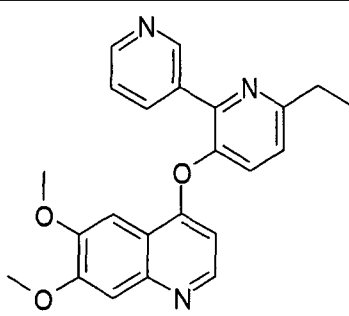
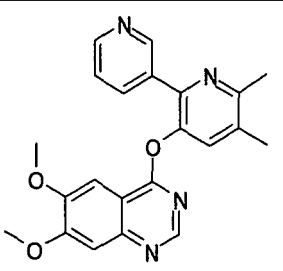
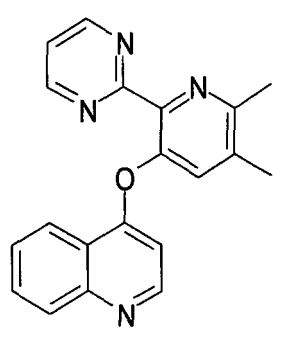
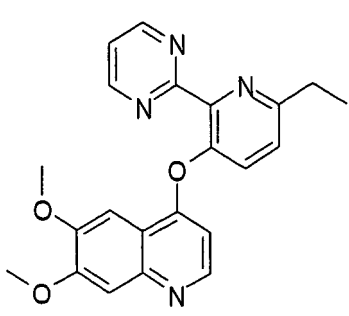
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
39		99	88	
41		98	66	
43			84	45
44		99	82	

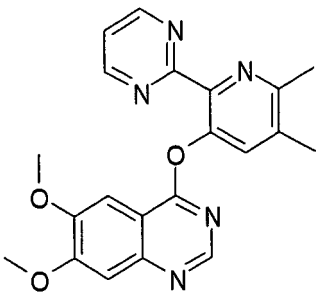
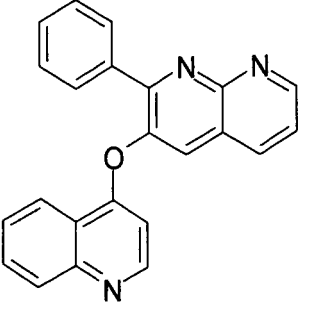
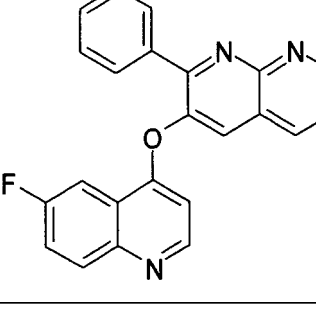
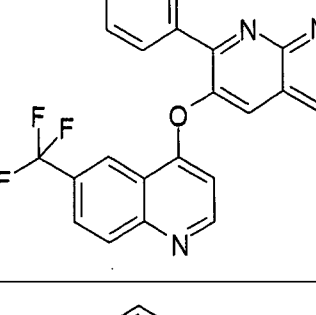
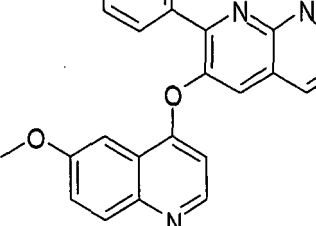
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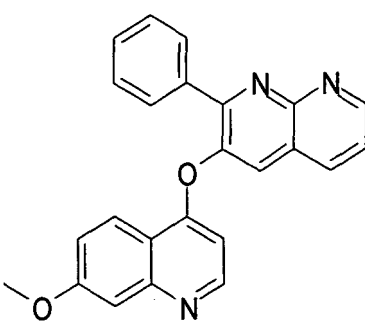
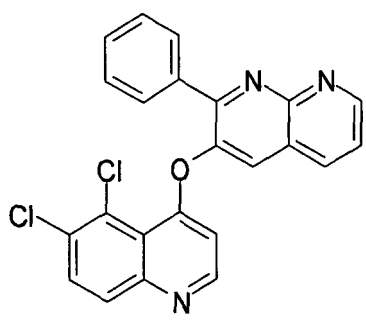
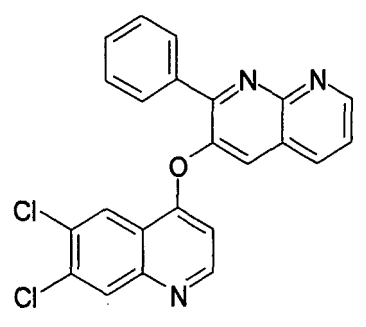
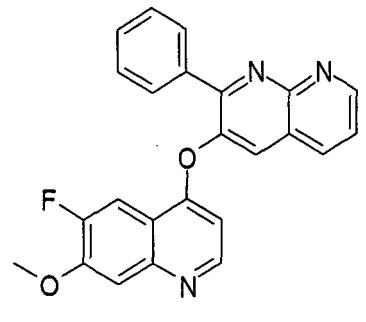
Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
45		100	89	
46		100	100	
48			64	28
49		100	97	
50		100	98	

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(continued)

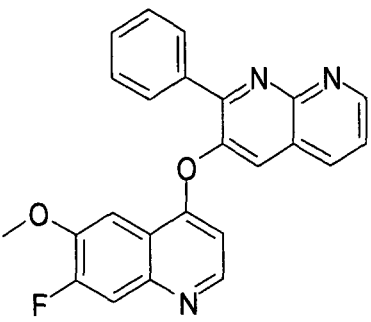
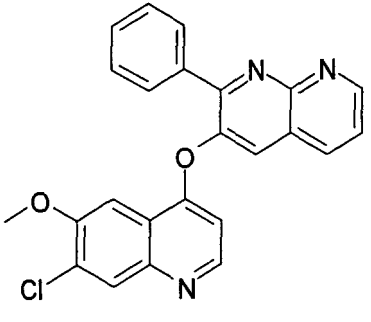
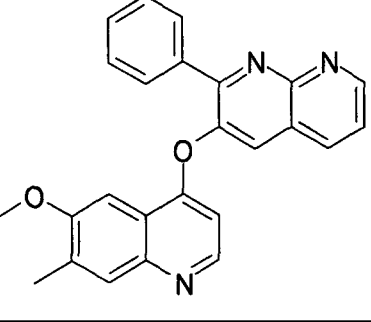
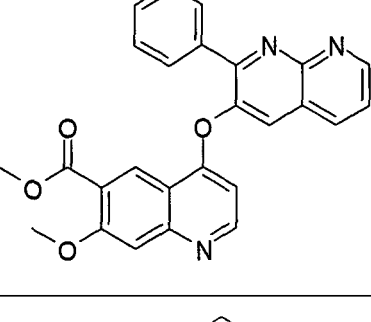
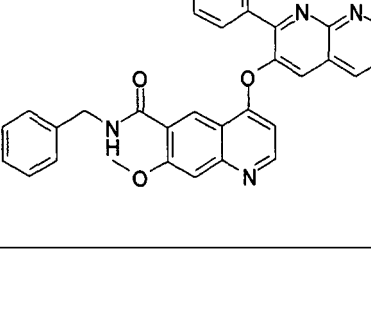
Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
51		100	93	
52		100	96	
53			83	43
54		99	76	
55		100	94	

(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
56		100	99	
57		100	75	
58		100	83	
59				93

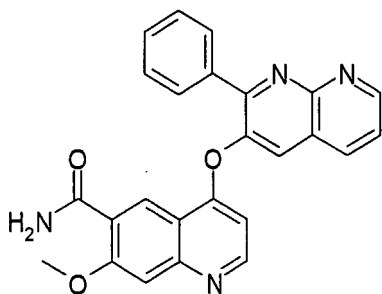
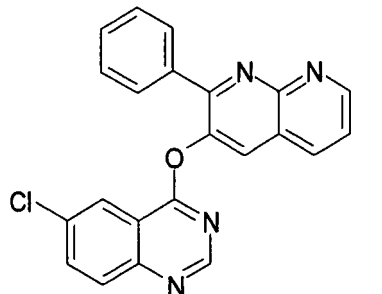
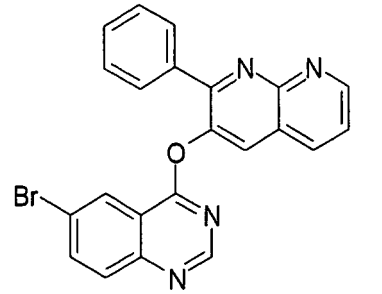
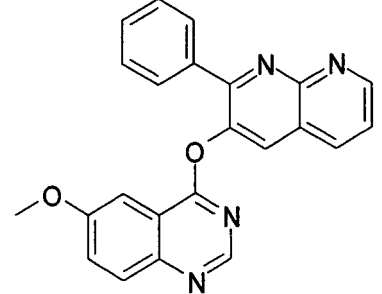
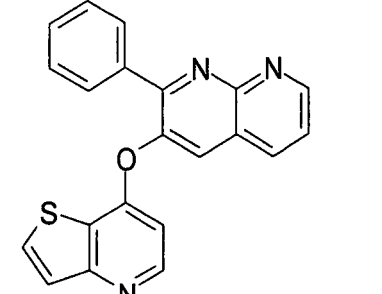
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
5 10 15 60		100	76	
20 25 61		100	98	
30 35 62		100	99	
40 45 63		100	99	
50 55 65		100	97	

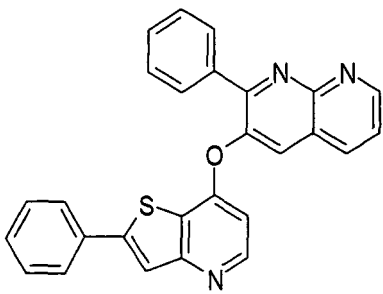
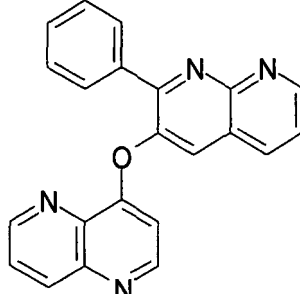
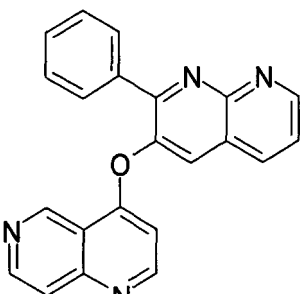
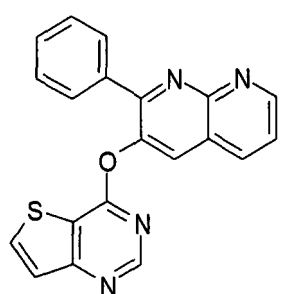
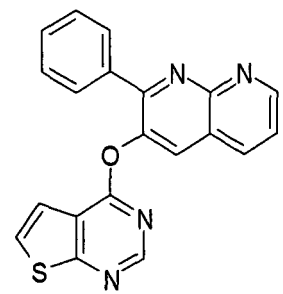
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
66			100	97
68		91	43	
69		94	52	
70		95	61	
71		100	93	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
72			99	81
73		80	26	
74		90	53	
75		98	84	
76		83	44	

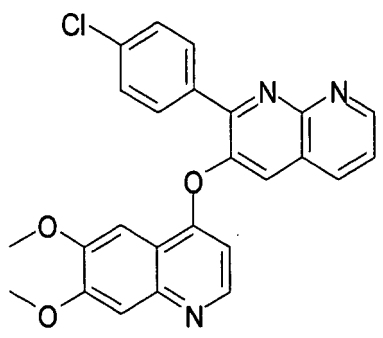
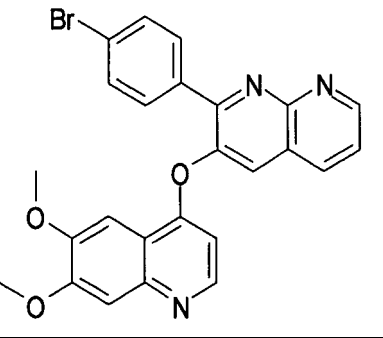
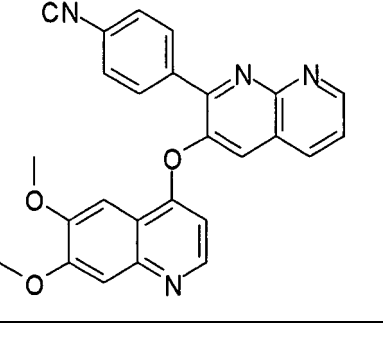
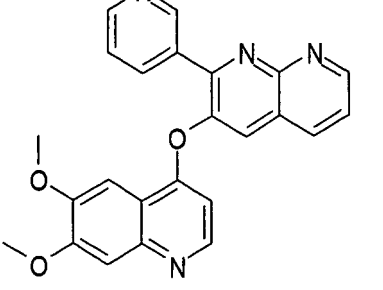
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
77		99	93	
78		99	75	
81		100	97	
82		67	25	
83		99	92	

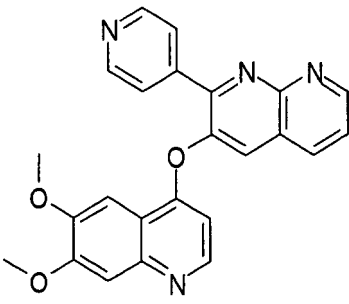
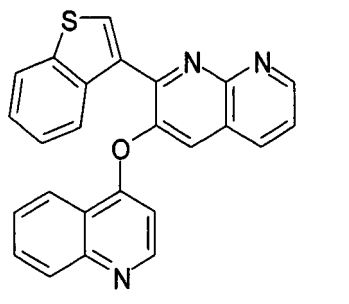
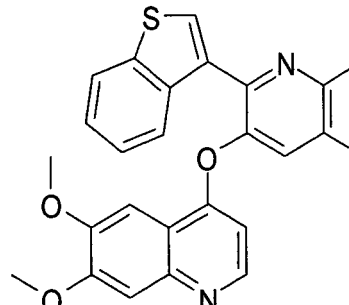
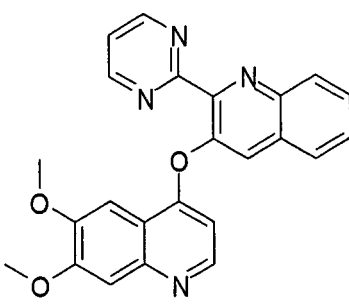
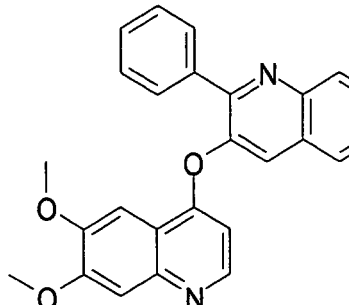
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
84		100	69	
85		97	48	
86		74	26	
88		100	90	

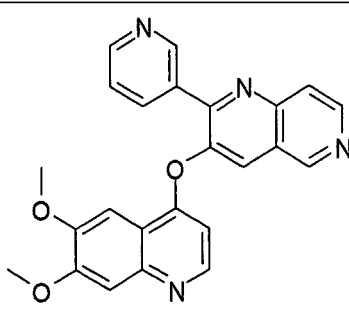
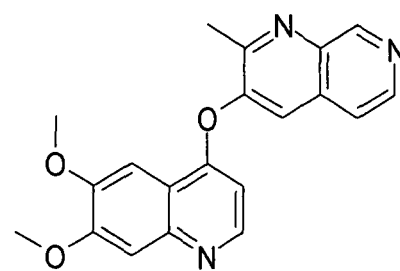
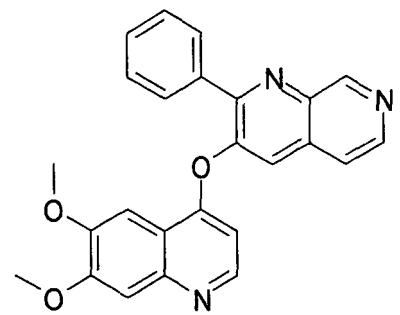
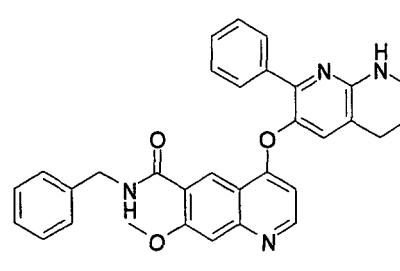
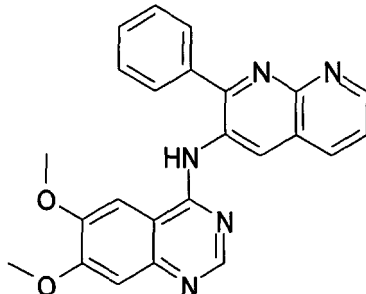
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
89		77	36	
90		68	22	
91		100	97	
92			98	62
93		100	97	

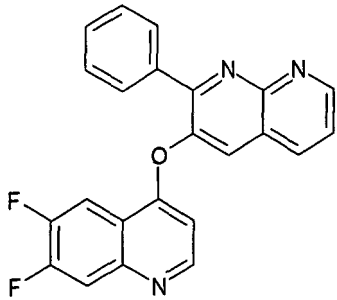
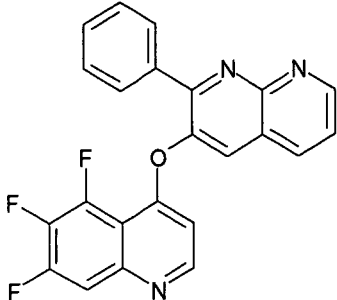
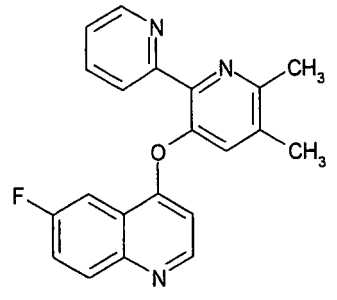
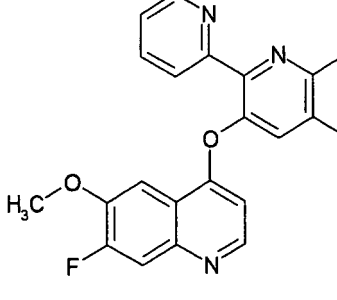
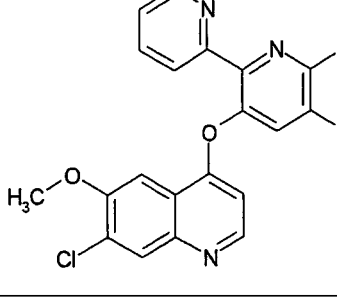
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
95		85	40	
97		88	52	
98		100	94	
99		92	76	
100		93	56	

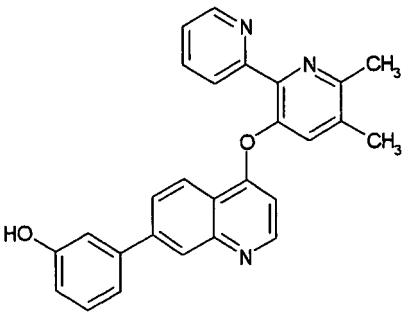
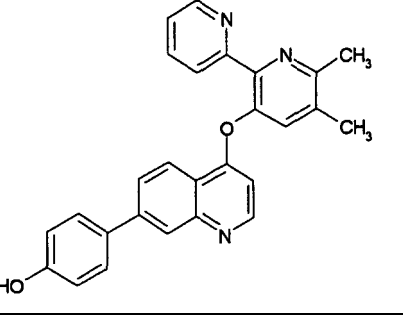
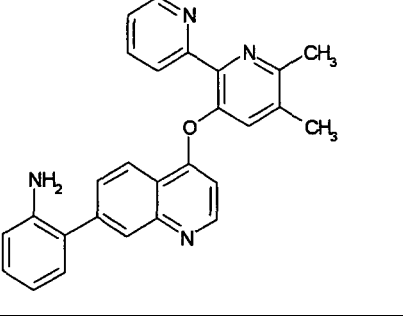
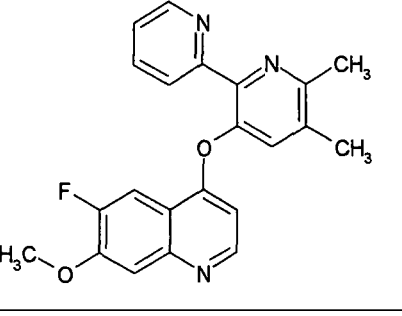
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
101		98	54	
102		92	45	
103		100	99	
104		100	99	
105		100	100	

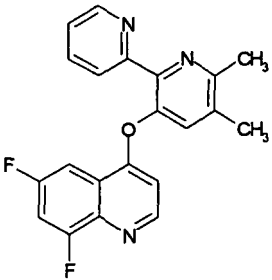
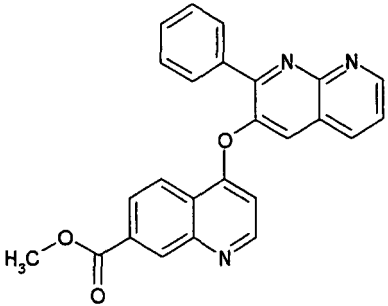
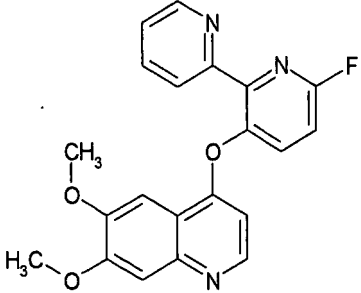
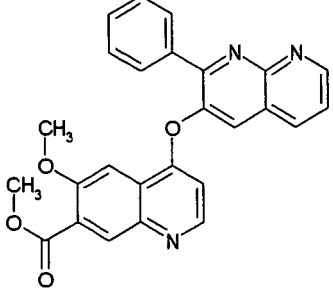
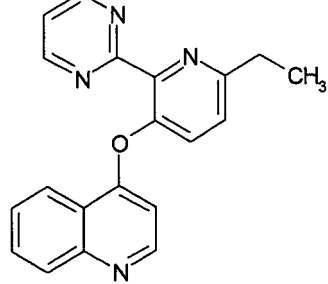
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
106		100	99	
107		100	100	
108		100	96	
110		100	100	

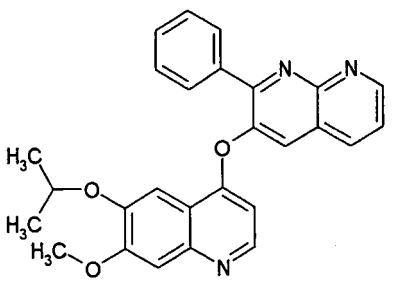
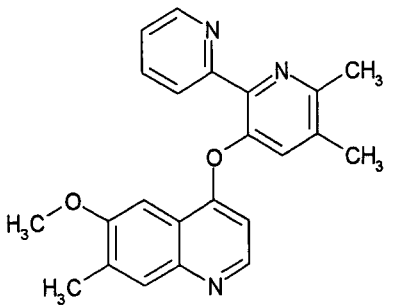
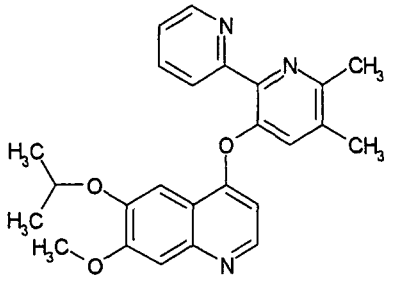
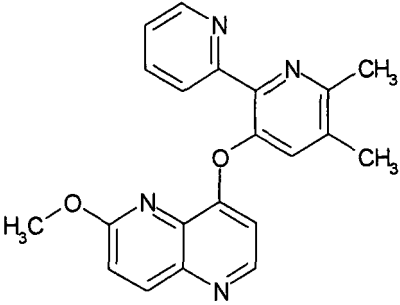
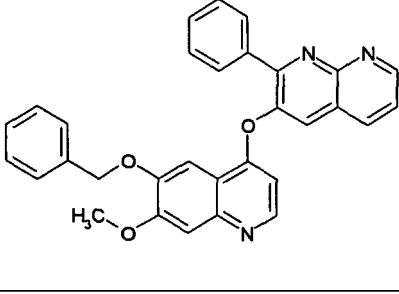
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
111		84	43	
113		100	95	
115		100	100	
116		100	99	
117		100	96	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
118		100	100	
119		100	100	
120		100	94	
121		100	98	
123		100	99	

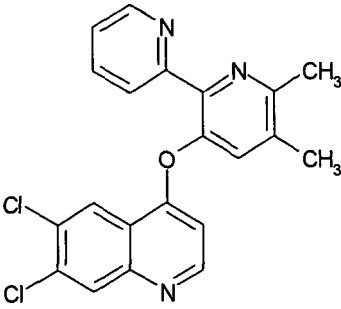
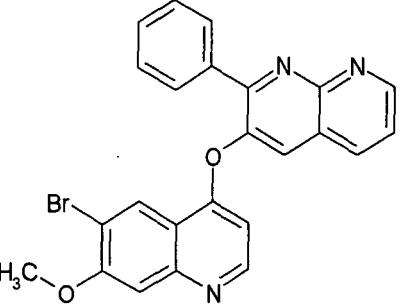
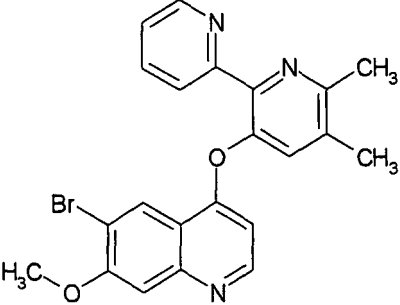
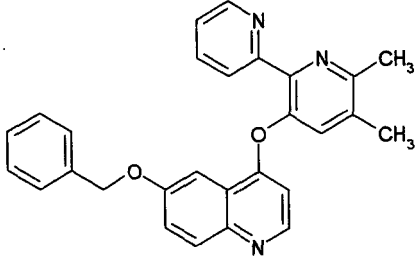
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
124		100	99	
125		100	99	
126		100	93	
128		100	93	
130		100	100	

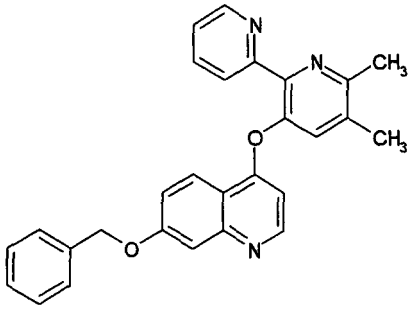
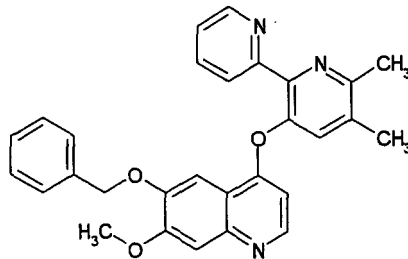
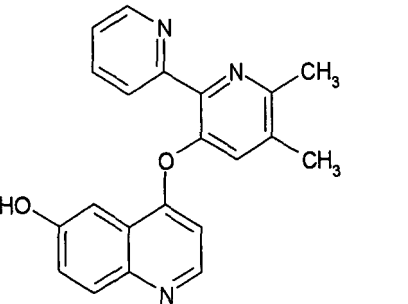
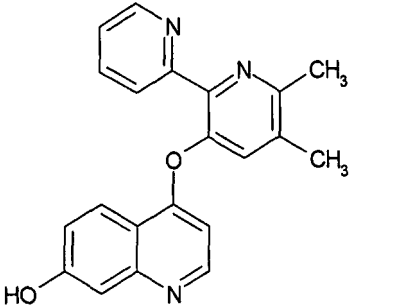
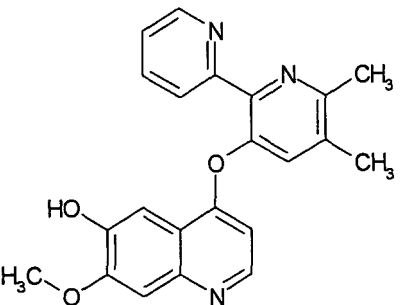
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
131		100	99	
132		100	98	
133		100	99	
136		100	93	

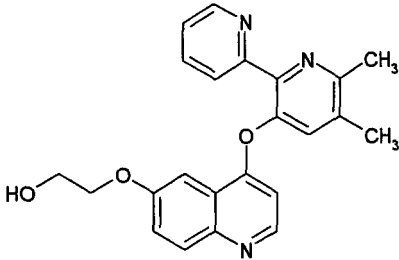
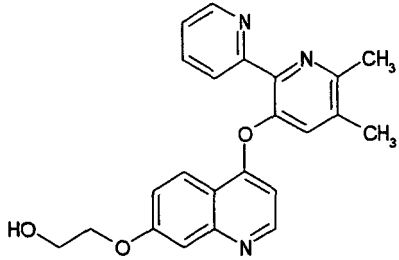
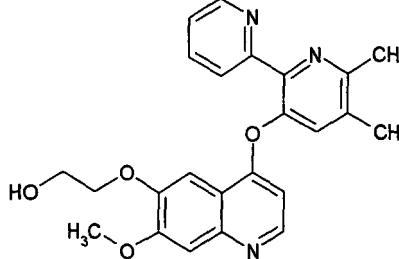
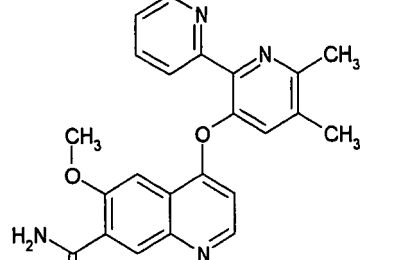
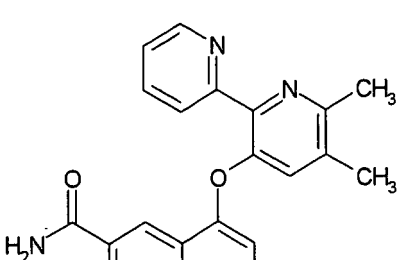
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
137		100	88	
138		100	98	
139		100	100	
140		100	99	
141		100	100	

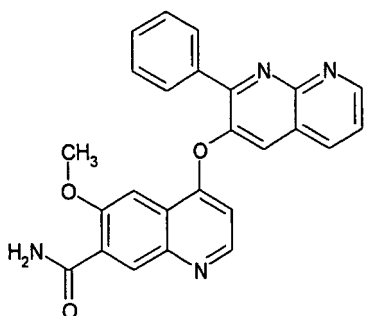
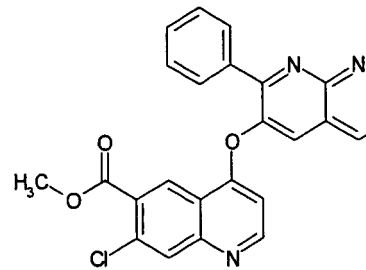
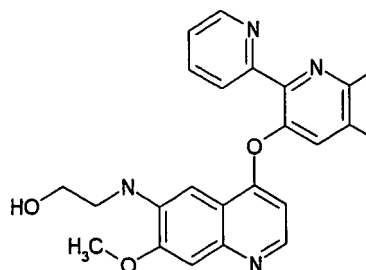
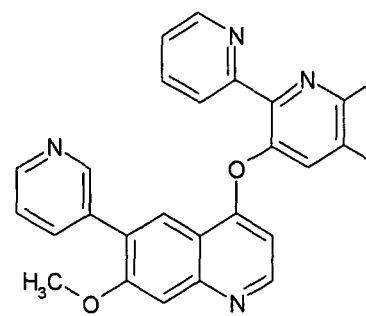
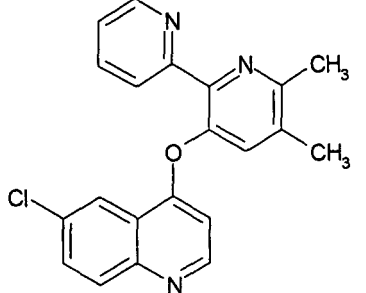
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
142		100	98	
143		100	100	
144		100	93	
145		100	78	
146		95	54	

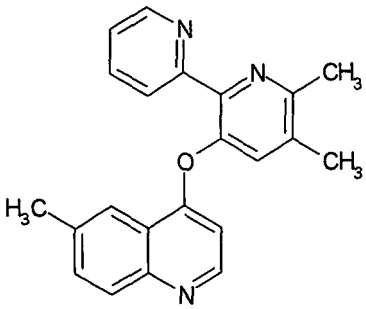
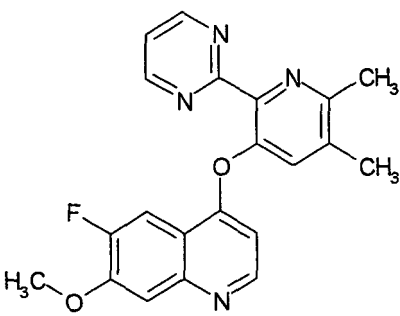
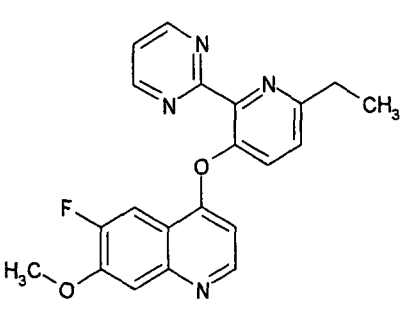
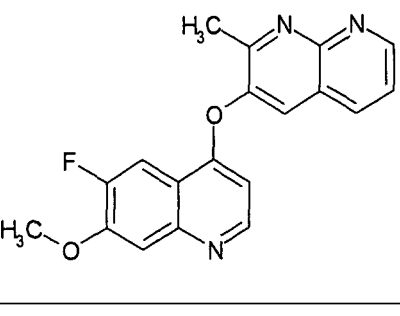
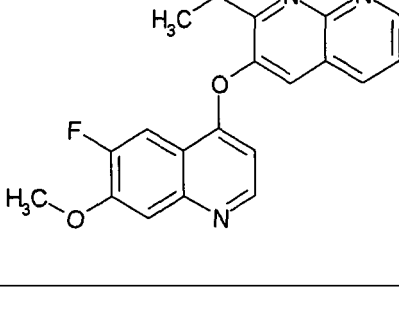
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
147		77	34	
148		98	58	
154		100	99	
155		100	99	
156		100	100	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
157		100	99	
158		100	98	
159		100	99	
160		87	56	
161		95	68	

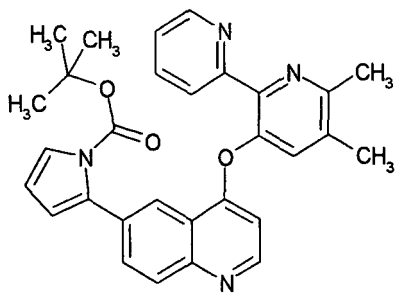
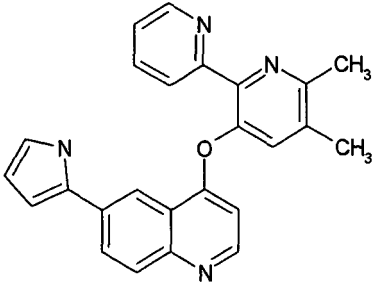
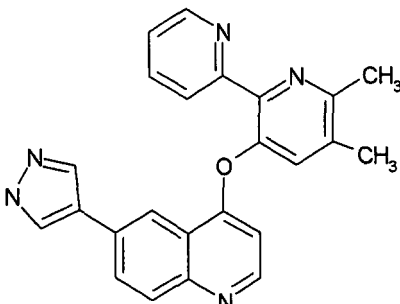
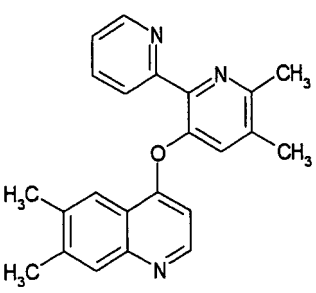
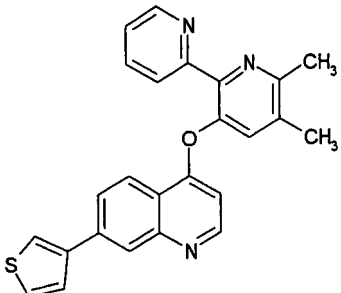
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
162		100	100	
163		100	92	
164		100	75	
165		100	90	
166		100	78	

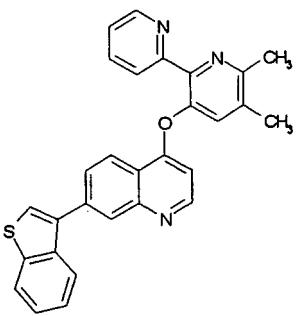
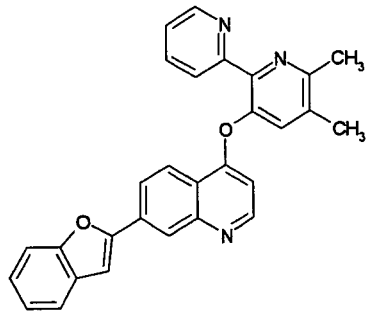
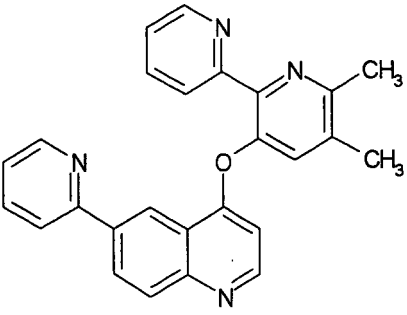
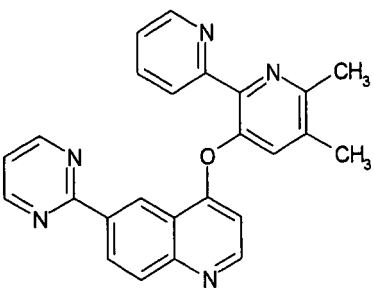
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
167		85	35	
168		100	92	
169		100	100	
170		100	98	
171		100	100	

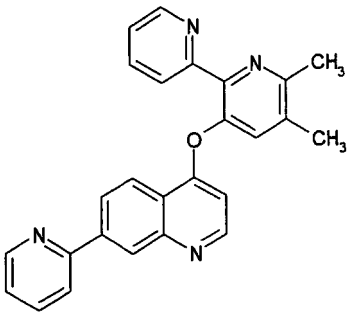
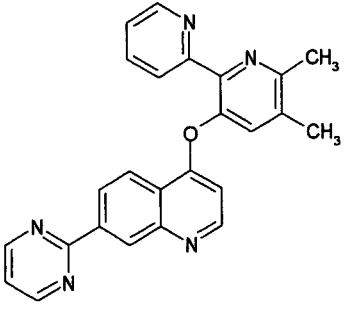
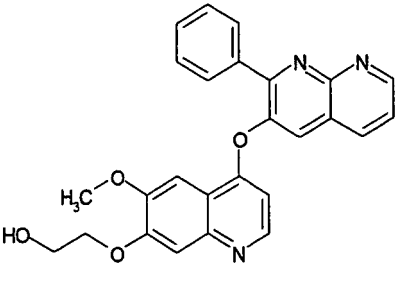
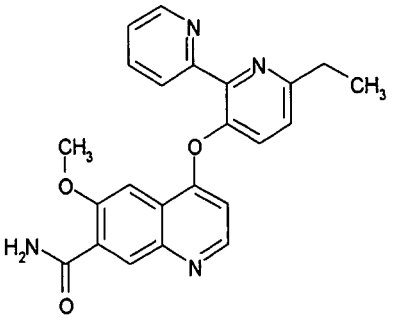
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
172		90	49	
173		92	57	
174		100	89	
175		100	97	

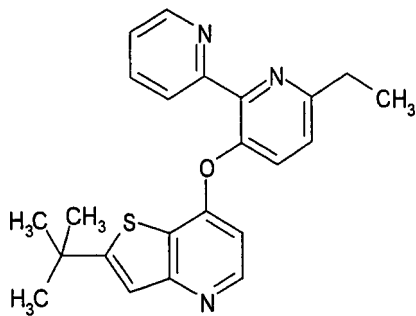
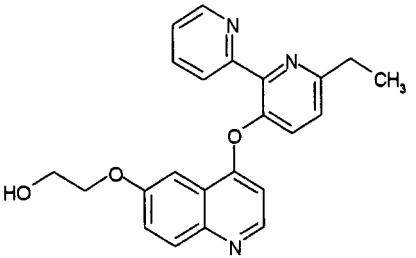
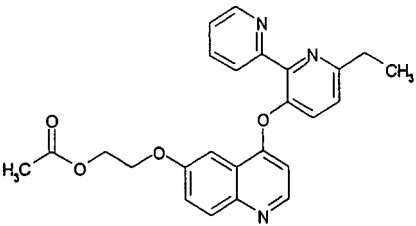
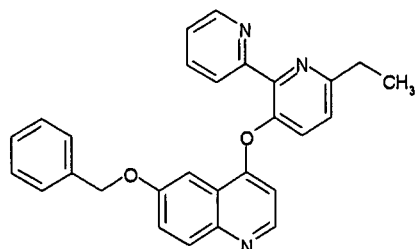
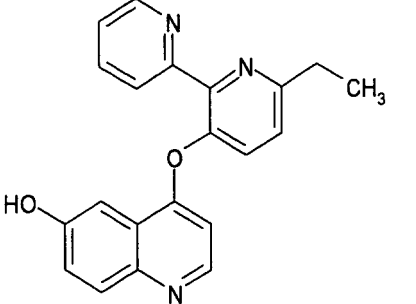
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
176		100	99	
177		100	98	
178		100	100	
179		100	100	

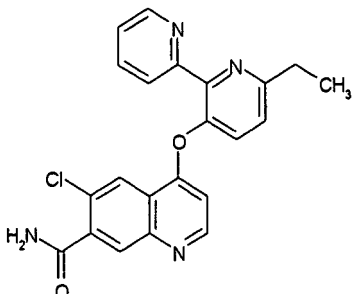
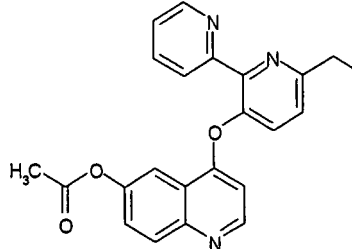
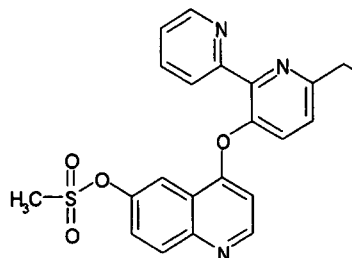
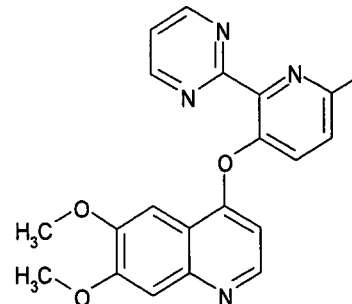
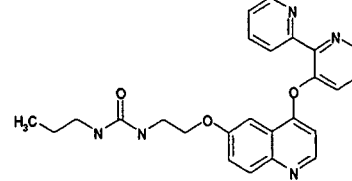
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
180		98	74	
181		100	100	
182		100	99	
183		100	100	
184		100	100	

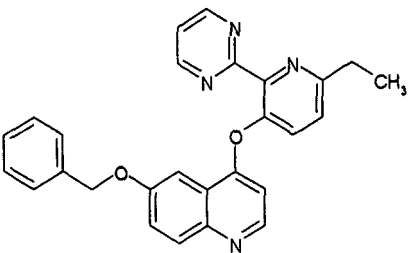
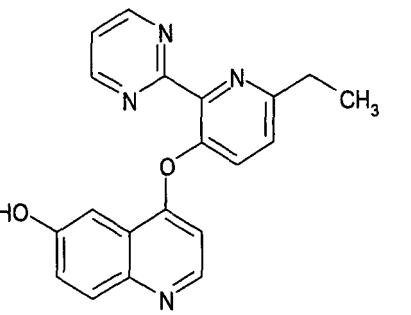
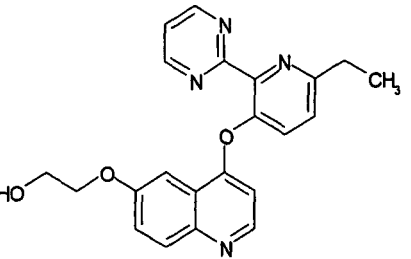
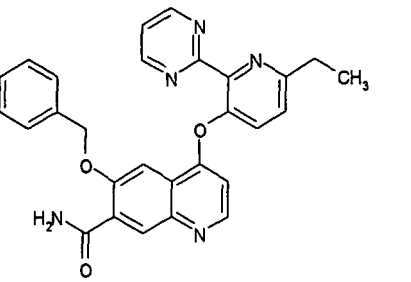
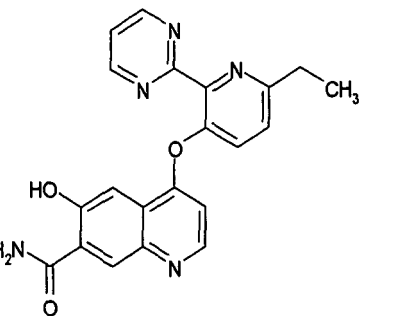
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
185		100	96	
186		100	100	
187		100	100	
188		100	100	
189		99	97	

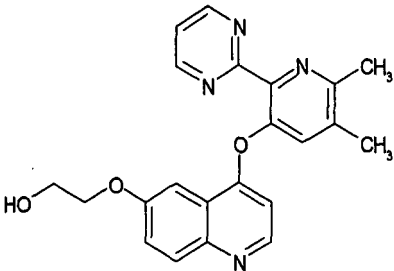
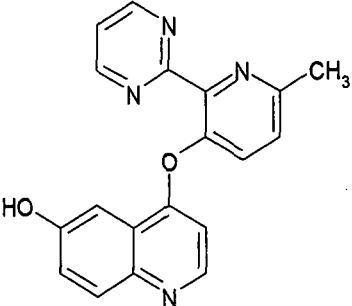
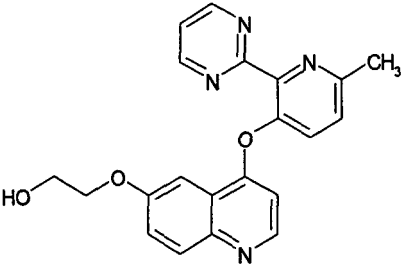
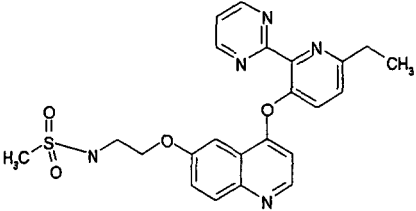
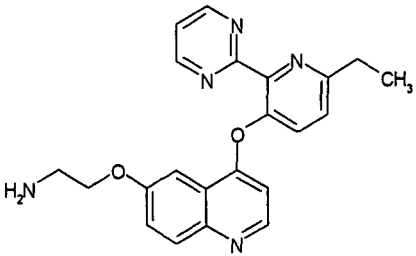
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
190		100	100	
191		100	99	
192		100	97	
193			80	
194			60	

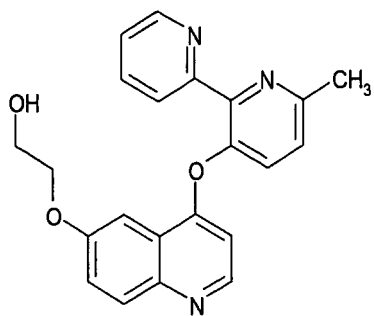
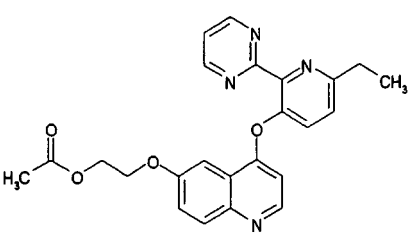
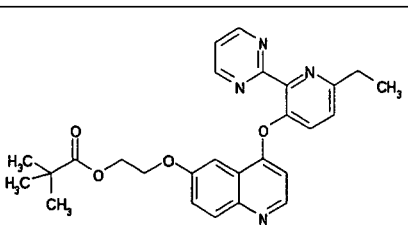
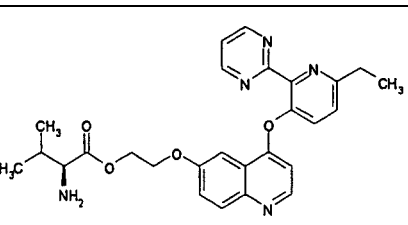
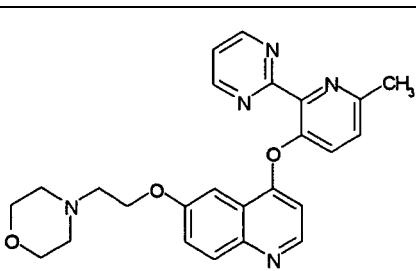
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
200			85	
201			82	
202			86	
203			79	
204			84	

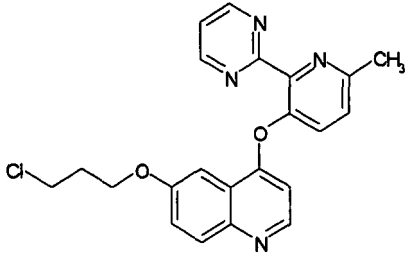
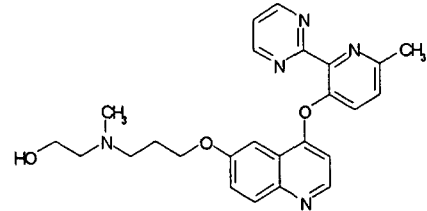
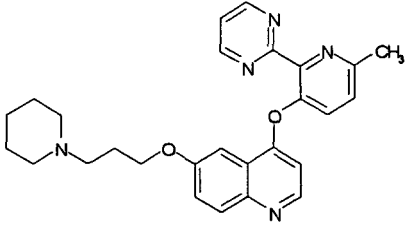
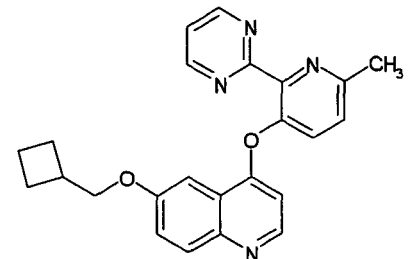
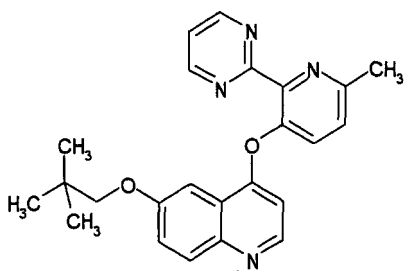
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
205			98	
206			89	
207			93	
208			75	
209			54	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
210			87	
211			54	
212			55	
213			98	
214			90	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
215			79	
216			84	
217		100	90	
218		100	84	
219		100	96	

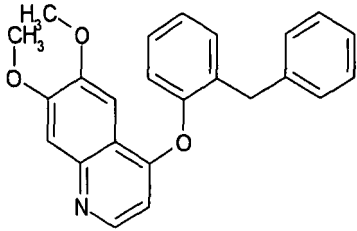
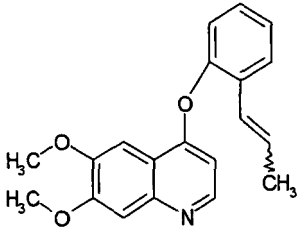
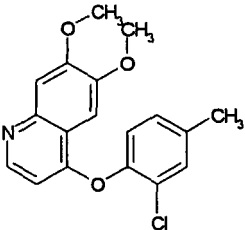
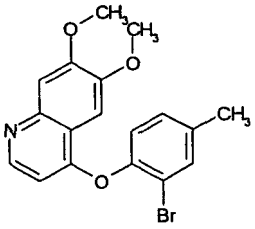
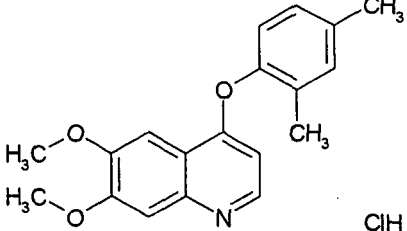
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
220		100	91	
221		79	39	
222		100	91	
223		90	52	
224		100	95	
225		99	89	

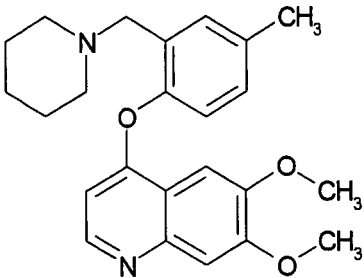
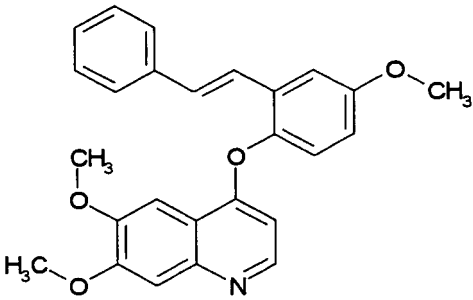
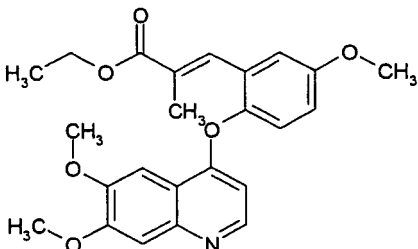
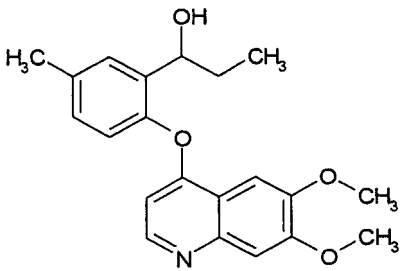
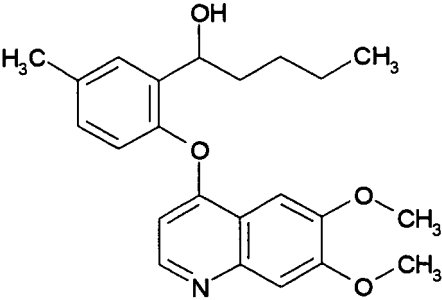
[0543] Table 1B:

[Table 1B]

Compound	Molecular structure	TGF β inhibition rate, %	
		10 μ M	3 μ M
r1		53	5
r2		88	13
r3		75	0
r4		78	20
r5		56	13

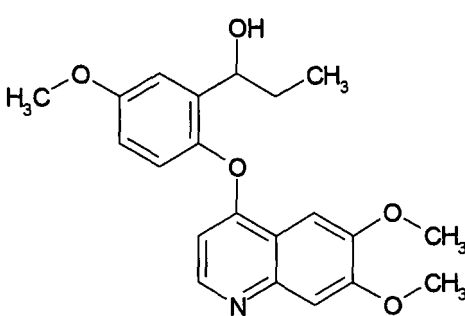
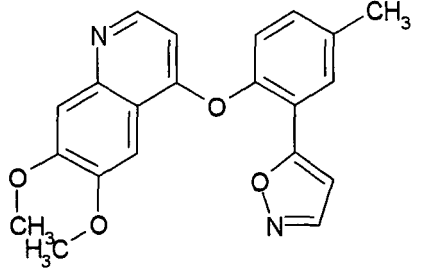
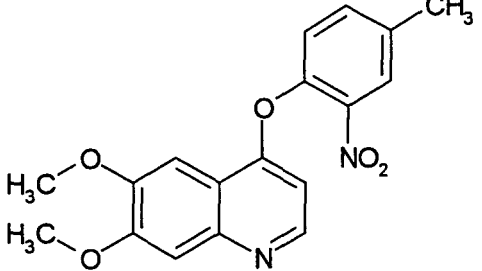
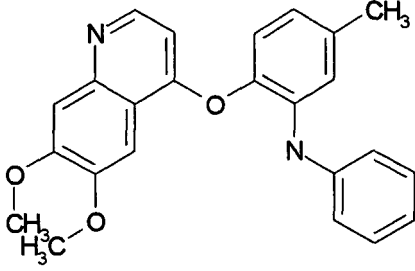
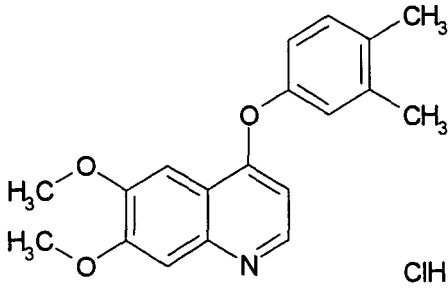
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r6		72	30
r7		54	13
r8		59	10
r9		77	29
r10		87	38

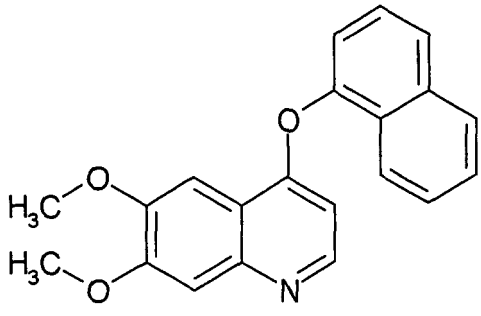
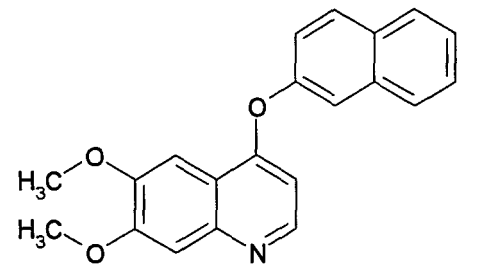
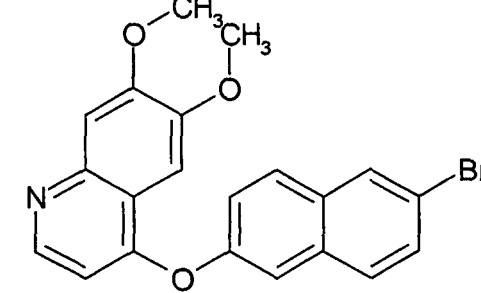
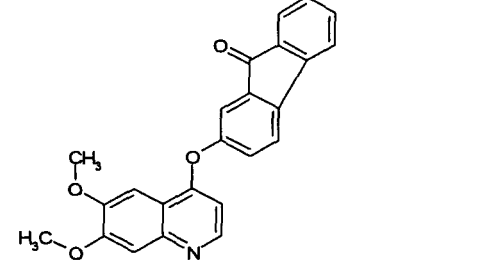
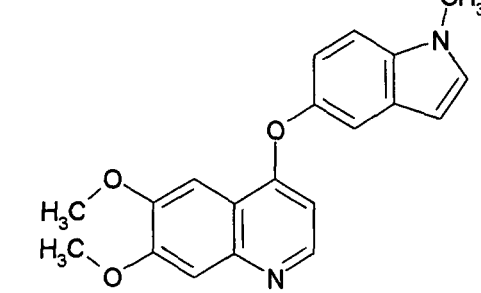
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 11		66	28
r12		89	21
r13		78	28
r14		64	15
r15	 ClH	84	41

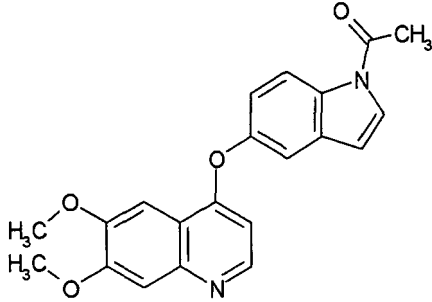
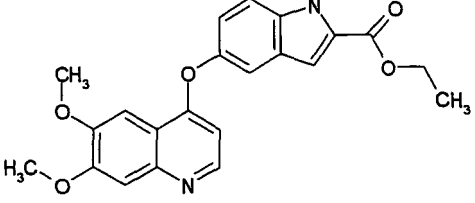
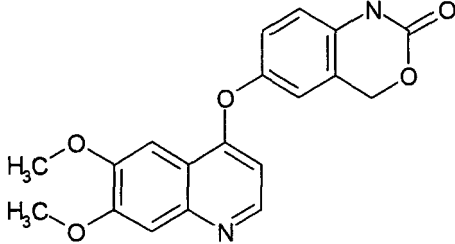
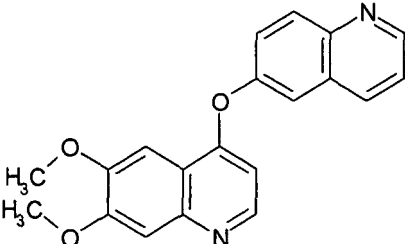
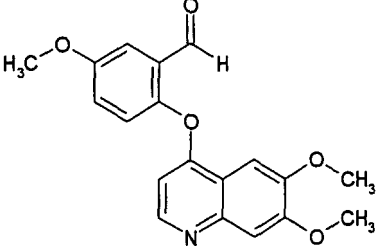
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r16		62	0
r17		80	15
r18		69	15
r19		95	73
r20		69	19

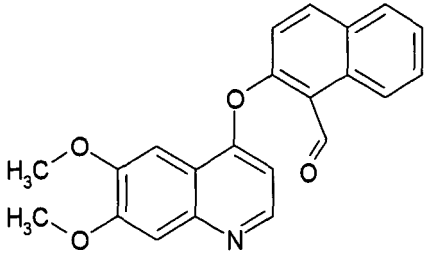
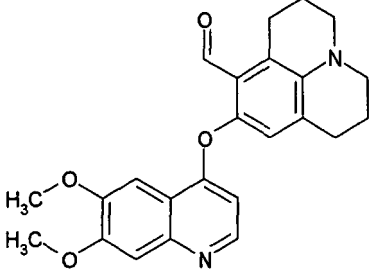
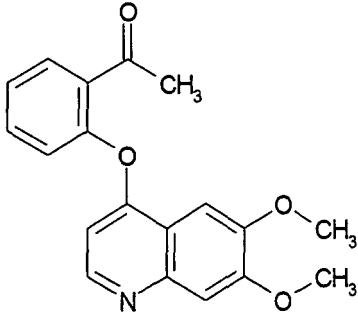
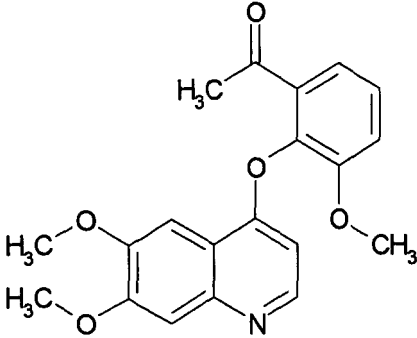
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 21		71	16
r 22		81	11
r 23		91	56
r 24		91	66
r 25			
r 26		73	20

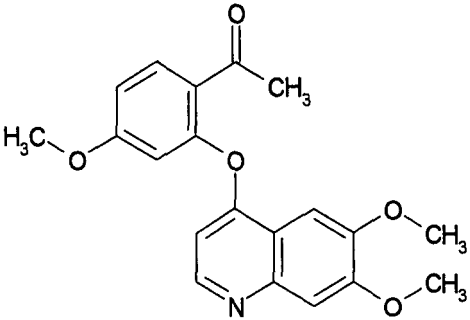
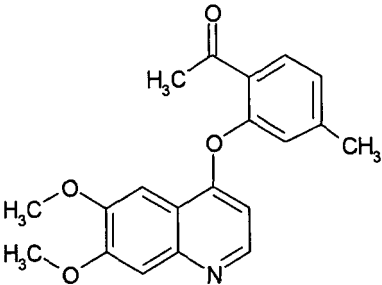
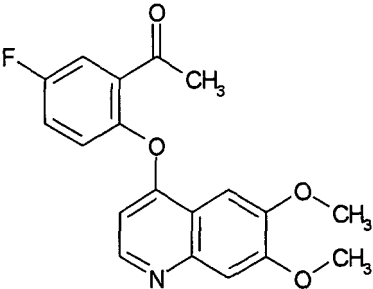
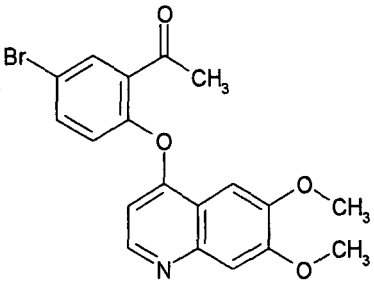
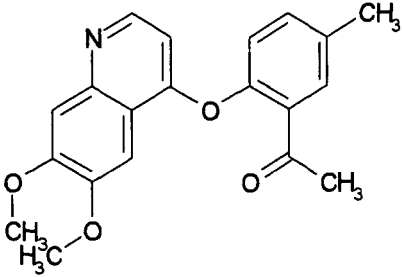
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 27		93	0
r 28		53	0
r 29		67	0
r 30		61	0

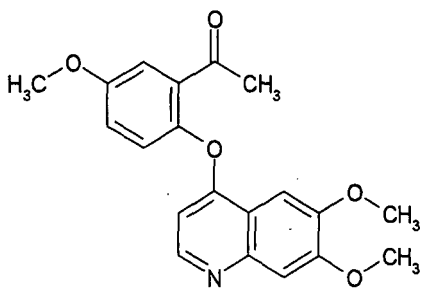
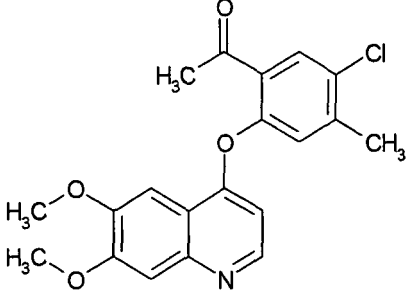
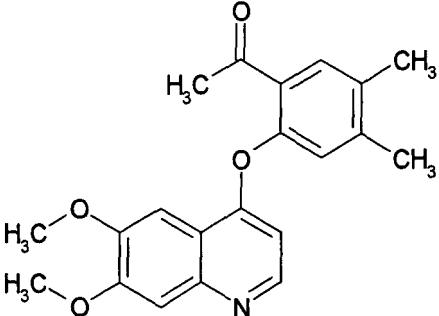
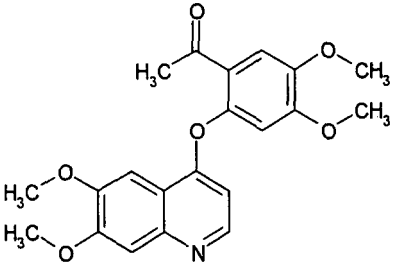
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 31		98	49
r 32		98	81
r 33		94	27
r 34		78	0
r 35		89	49

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 36		100	95
r 37		100	94
r 38		100	98
r 39		91	0

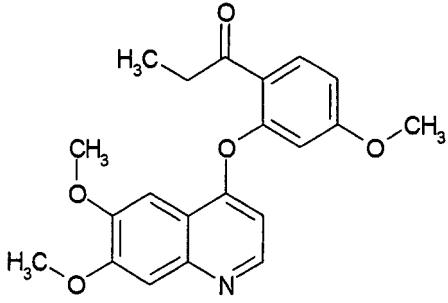
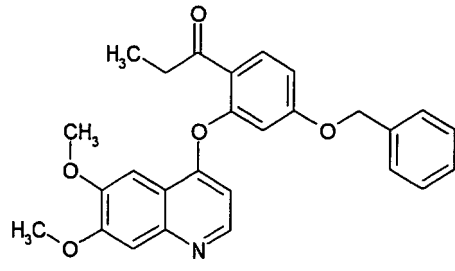
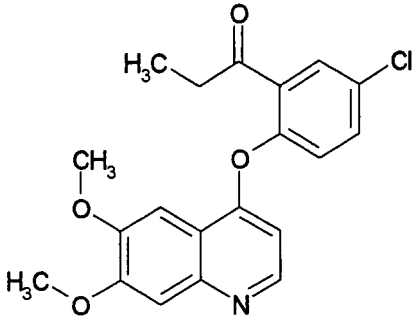
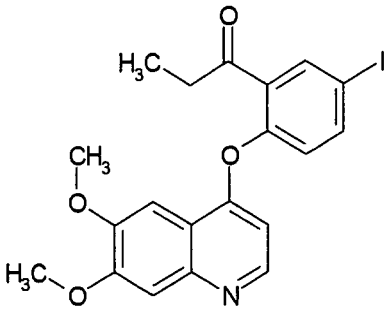
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 40		83	12
r 41		97	57
r 42		93	90
r 43		66	0

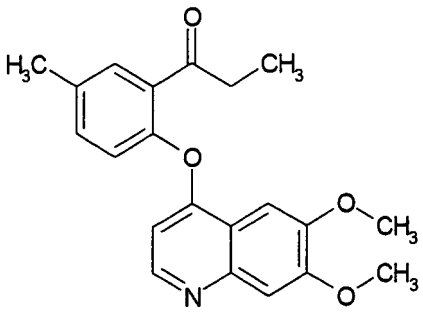
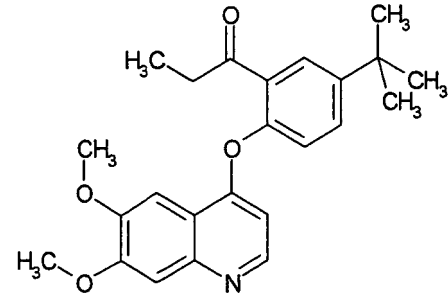
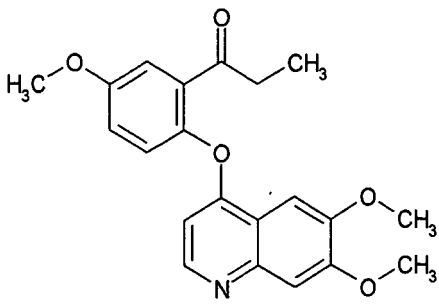
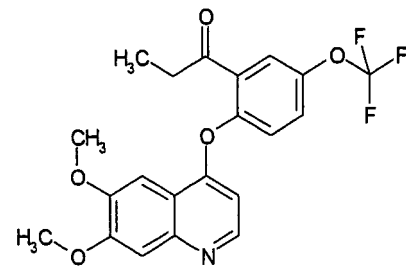
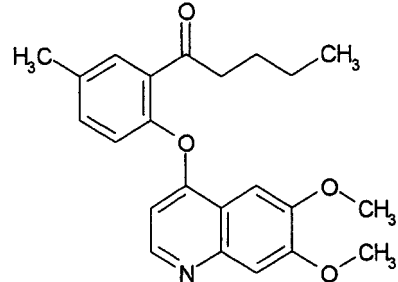
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %	
		10 μ M	3 μ M
r 44		100	97
r 45		67	0
r 46		100	70
r 47		98	45

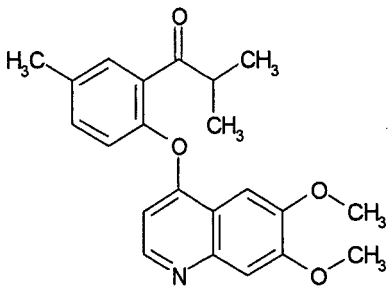
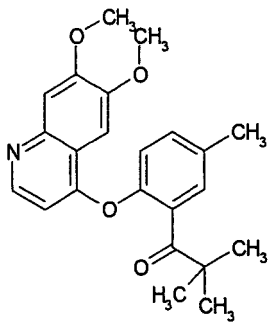
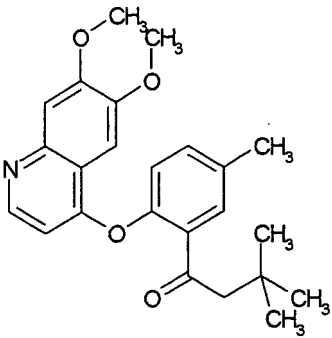
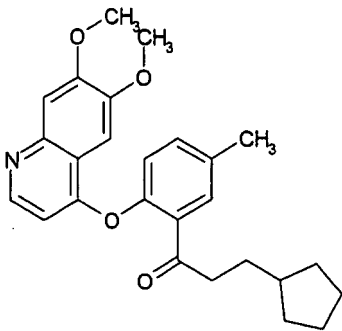
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 48		100	98
r 49		62	0
r 50		100	100
r 51		99	71
r 52		100	97

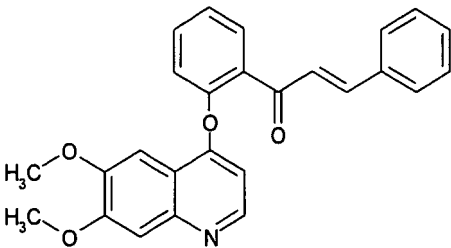
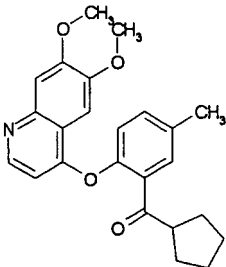
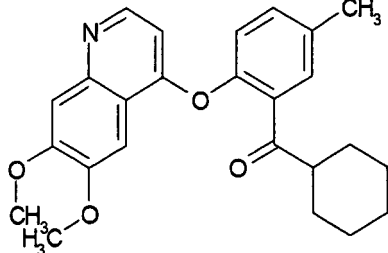
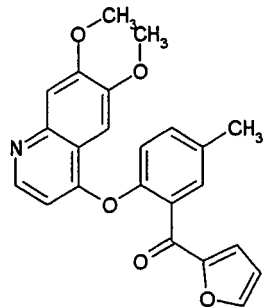
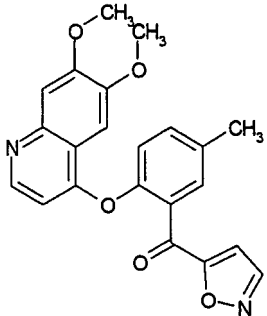
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 53		100	97
r 54		73	13
r 55		98	53
r 56		84	0

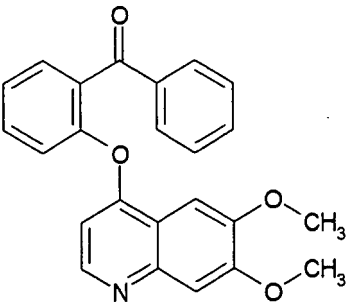
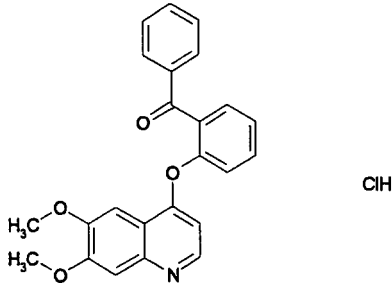
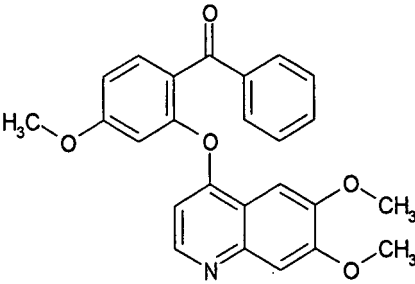
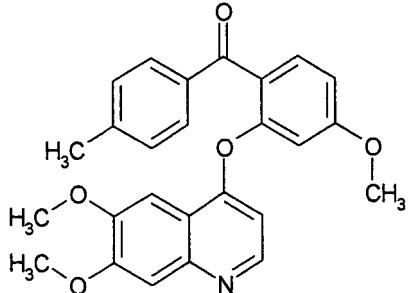
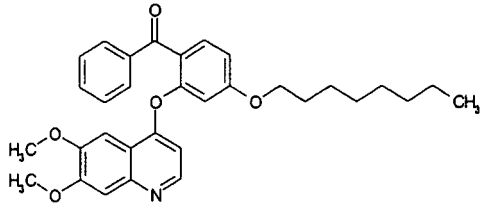
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 57		55	10
r 58		100	90
r 59		99	65
r 60		98	63
r 61		98	61

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 62		85	43
r 63		91	57
r 64		98	67
r 65		100	58
r 66		86	22

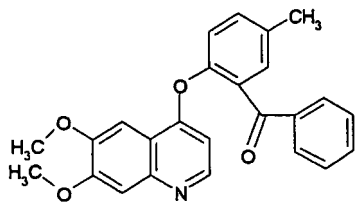
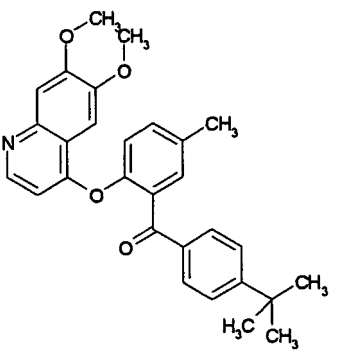
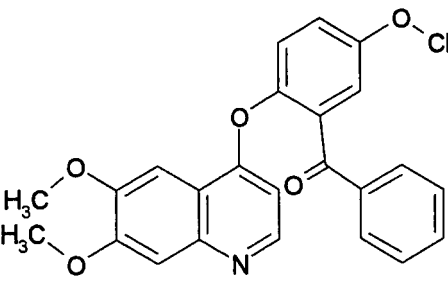
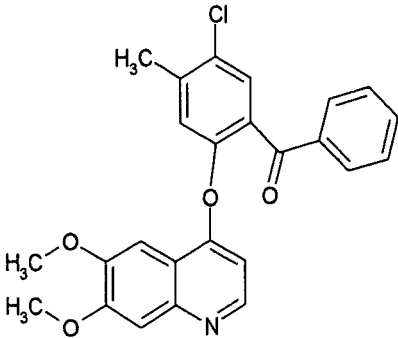
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 67		93	4
r 68		100	89
r 69		100	100
r 70		100	73
r 71		100	79

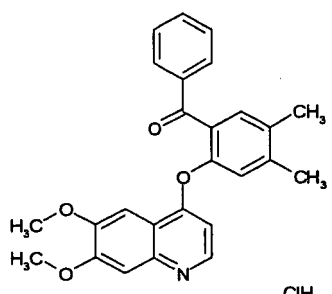
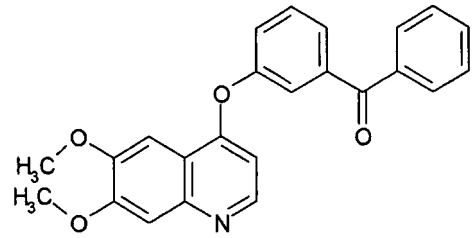
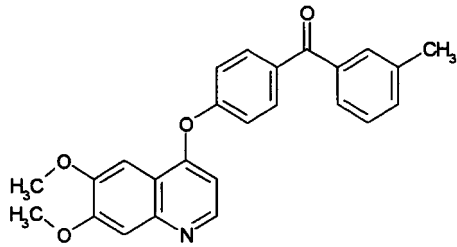
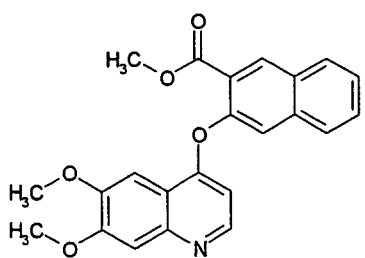
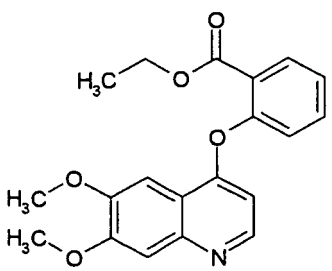
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 72	 <p>ClH</p>	100	98
r 73		81	24
r 74		84	27
r 75		100	97

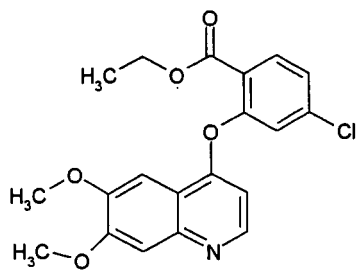
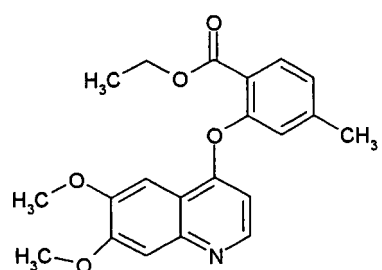
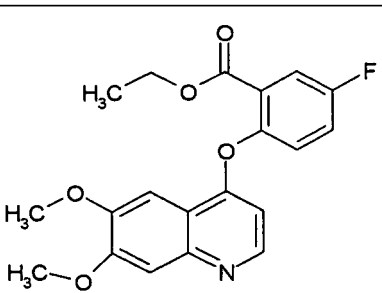
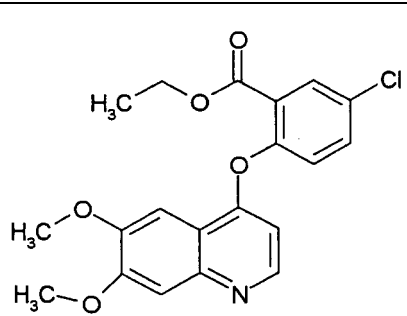
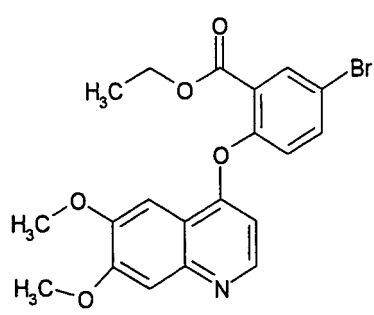
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 76	 <p style="text-align: center;">OH</p>	100	95
r 77		46	0
r 78		57	0
r 79		100	97
r 80		95	62

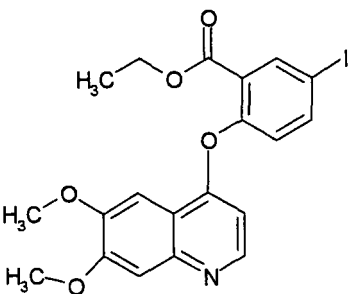
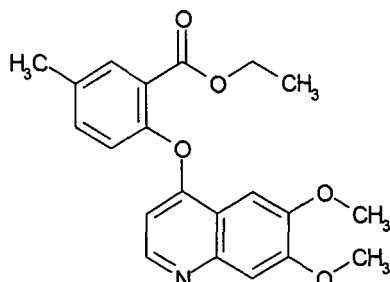
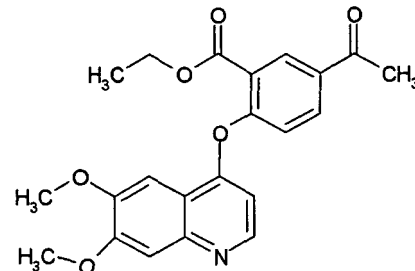
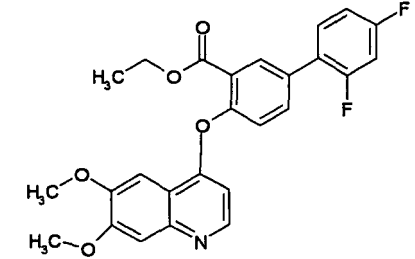
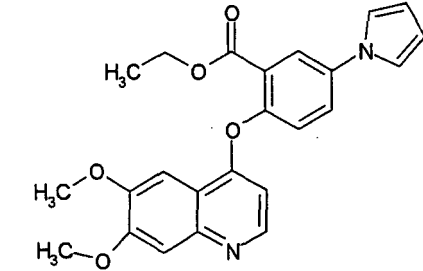
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 81		100	91
r 82		99	90
r 83		81	41
r 84		100	84
r 85		100	87

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 86		99	68
r 87		99	84
r 88		94	70
r 89		63	20
r 90		95	54

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 91		100	96
r 92		82	25
r 93		88	44
r 94		97	39
r 95		96	67

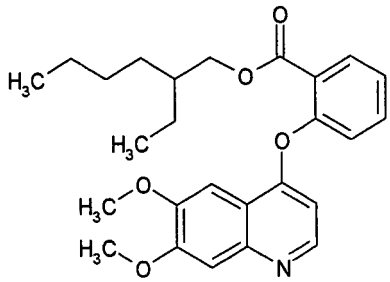
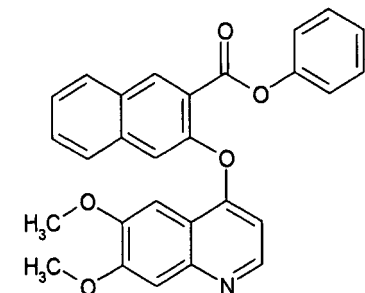
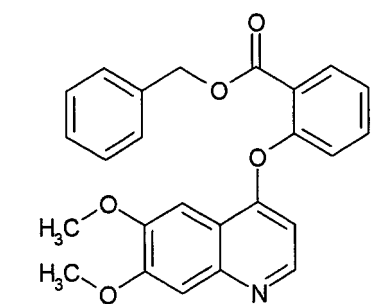
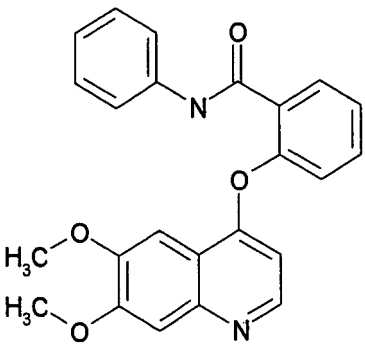
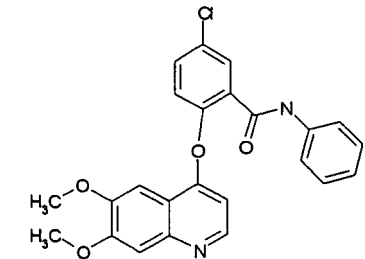
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 96		65	19
r 97		92	14
r 98		93	4
r 99		92	7
r 100		82	0

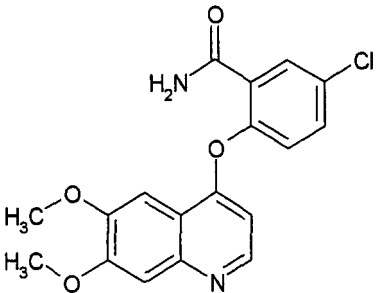
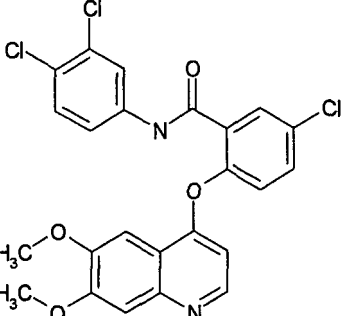
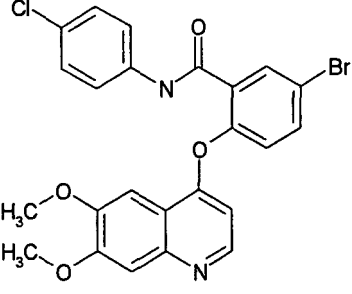
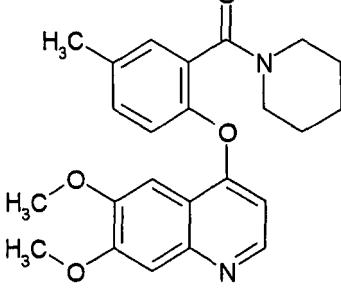
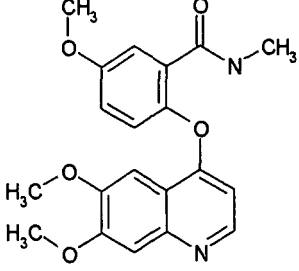
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 101		64	0
r 102		95	33
r103		84	20
r104		58	0
r 105		88	17

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 106		80	9
r 107		82	0
r 108		73	0
r109		66	5
r 110		93	55

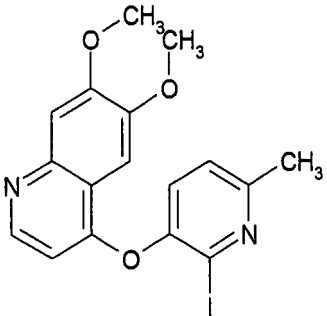
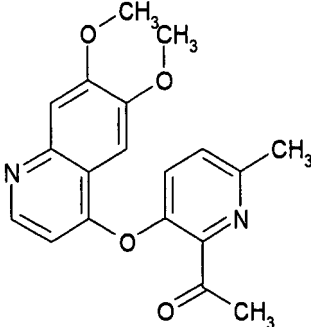
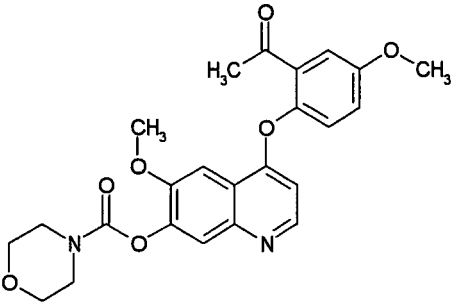
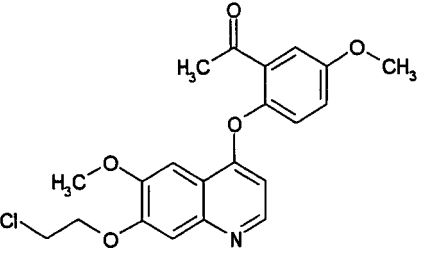
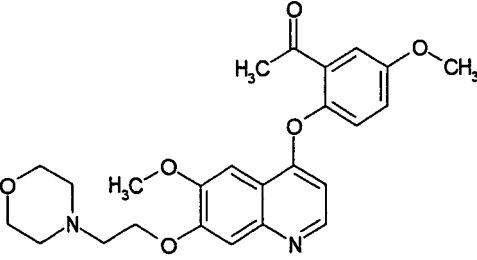
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 111		92	29
r 112		91	44
r 113		96	0
r114		96	0
r115		97	74

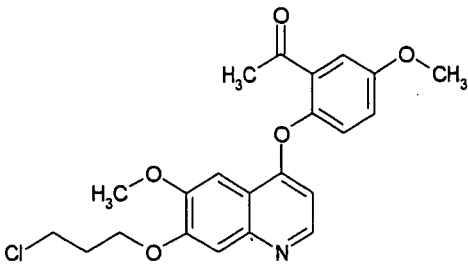
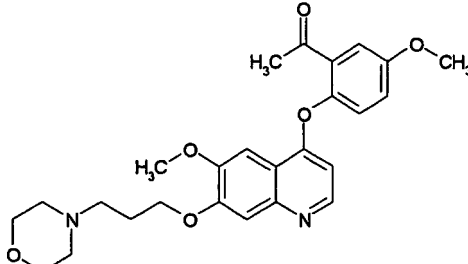
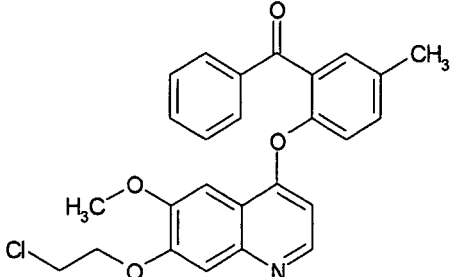
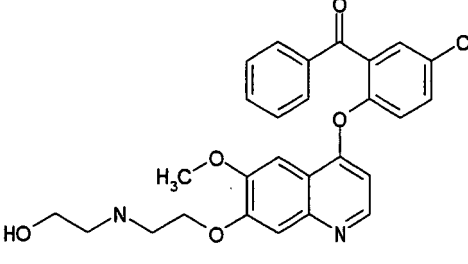
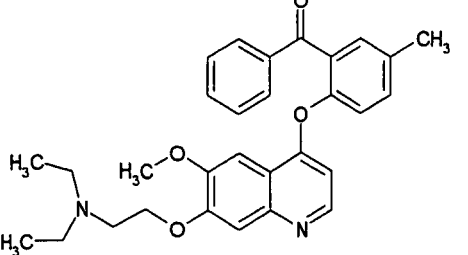
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r116		100	99
r117		98	84
r118		100	97
r119		97	96
r120		100	94

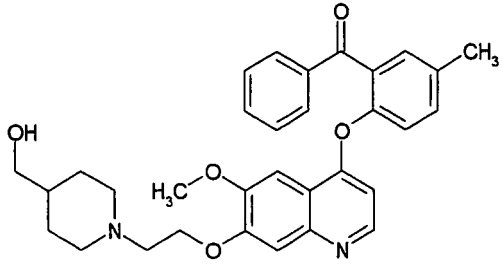
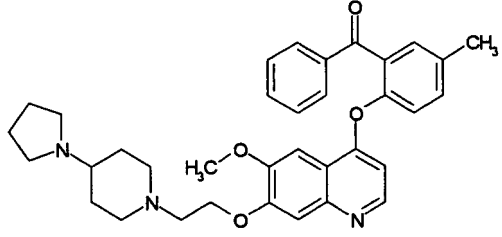
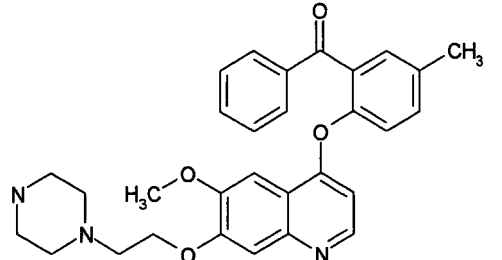
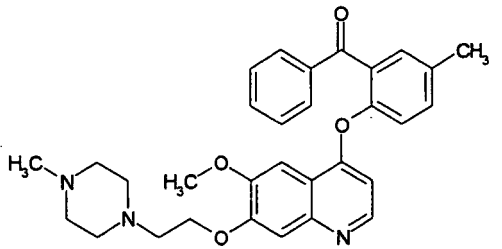
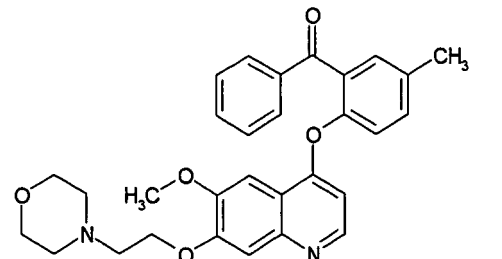
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 121		100	100
r122		100	100
r123		100	98
r124		100	99
r 125		100	98

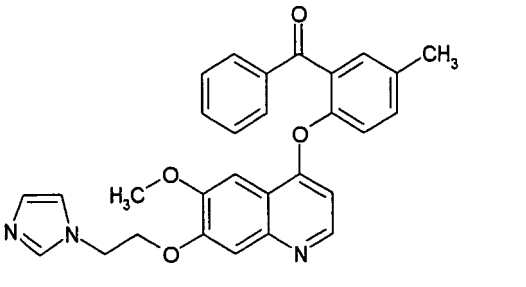
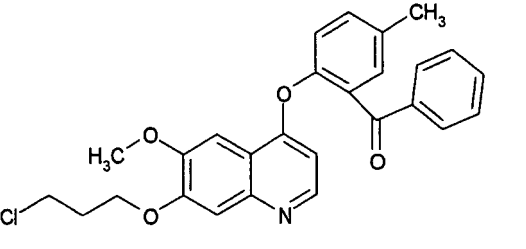
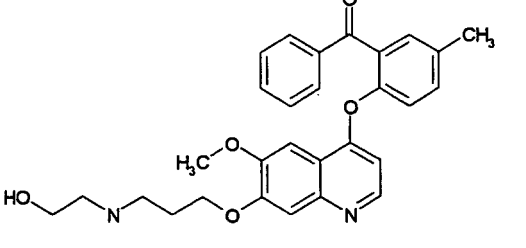
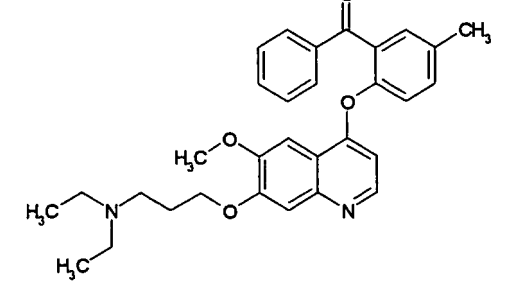
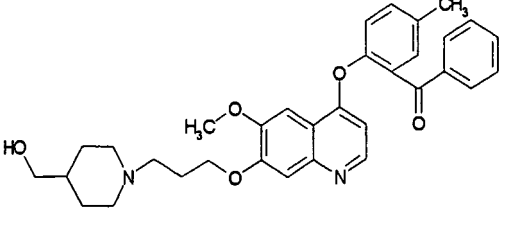
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 126		100	100
r 127		100	99
r 128		100	100
r 129		100	100
r 130		100	90

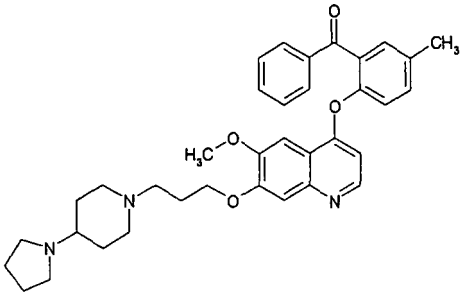
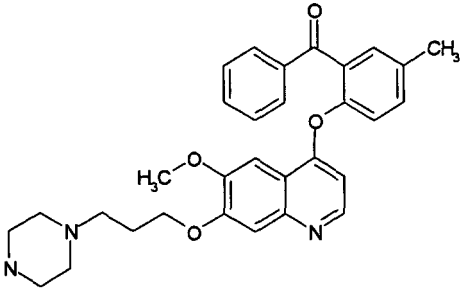
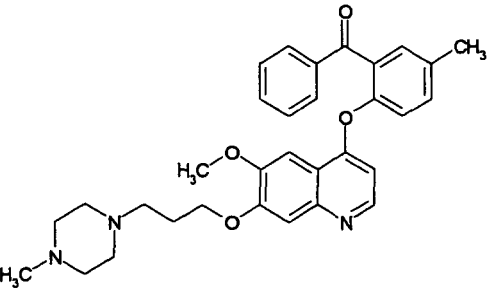
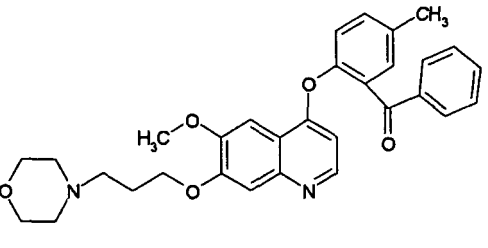
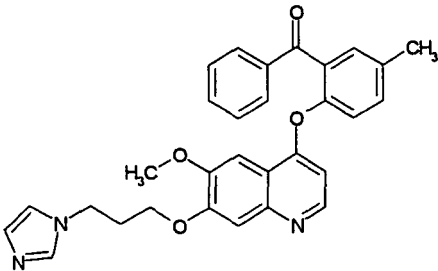
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 131		100	96
r 132		99	72
r 133		100	100
r 134		100	100
r135		100	100

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 136		100	90
r137		100	100
r138		100	96
r139		100	99
r140		100	85

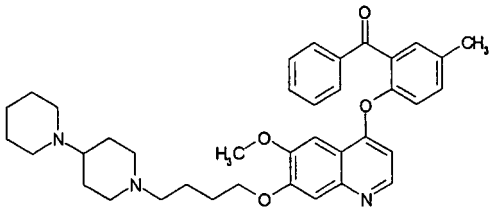
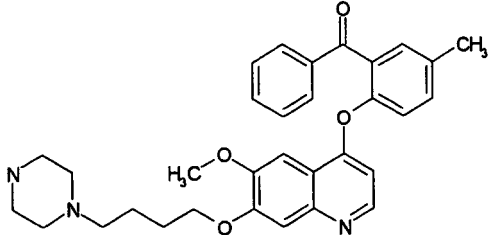
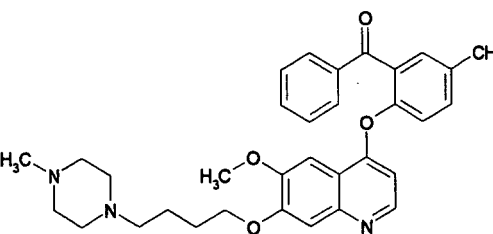
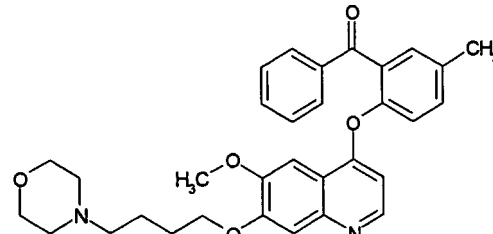
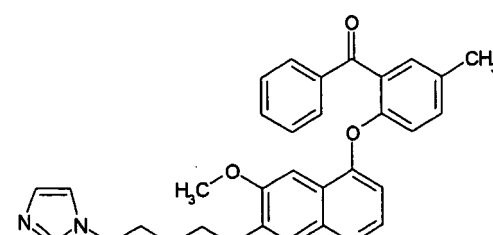
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 141		89	55
r142		100	100
r143		100	97
r 144		100	99
r 145		100	87

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 146		100	64
r 147		100	98
r 148		100	99
r 149		100	96
r 150		100	97

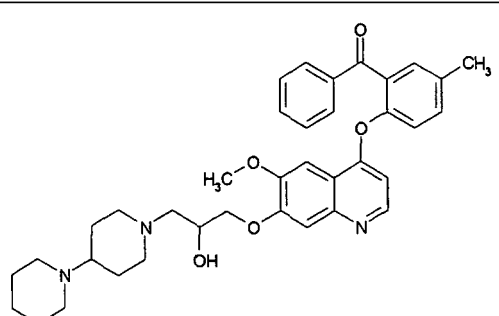
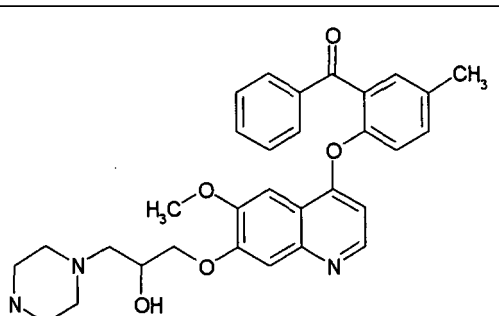
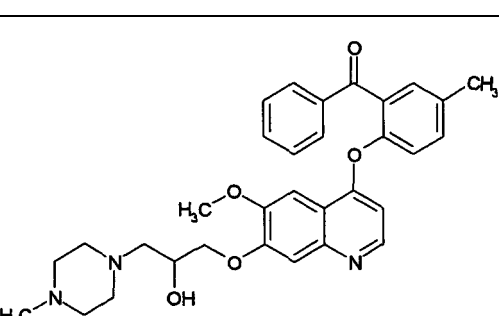
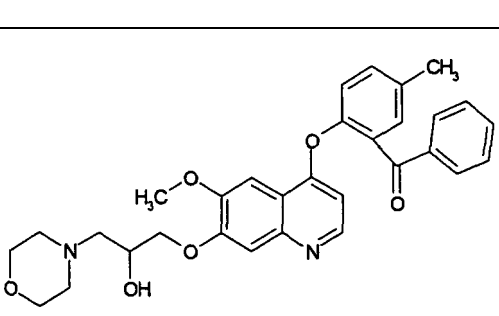
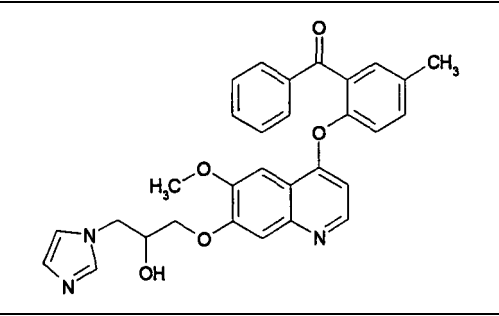
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 151		100	95
r 152		100	99
r153		100	100
r154		100	99
r155		100	100

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(continued)

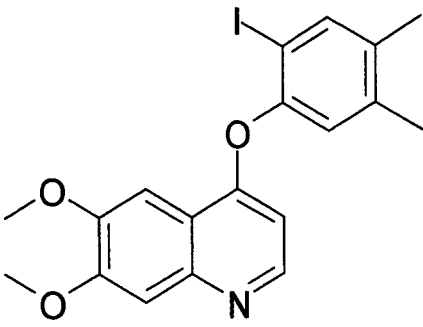
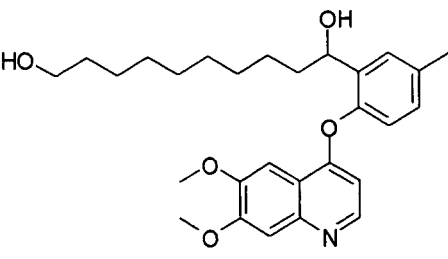
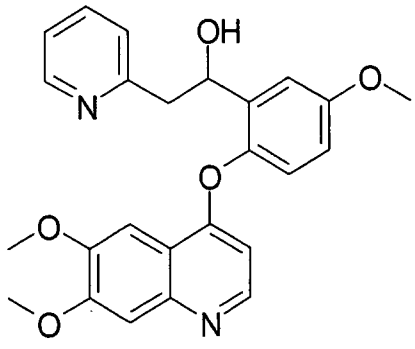
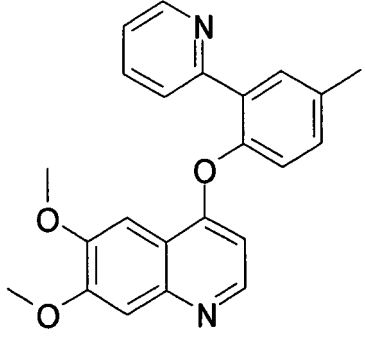
Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 156		100	99
r 157		100	100
r 158		100	100
r 159		100	98
r 160		100	98

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(continued)

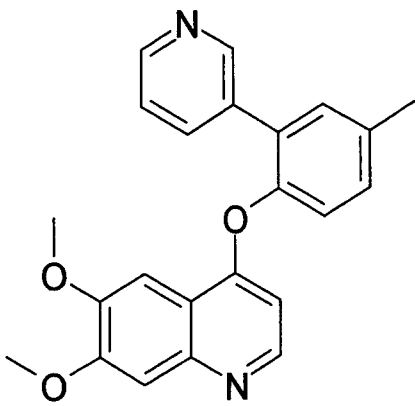
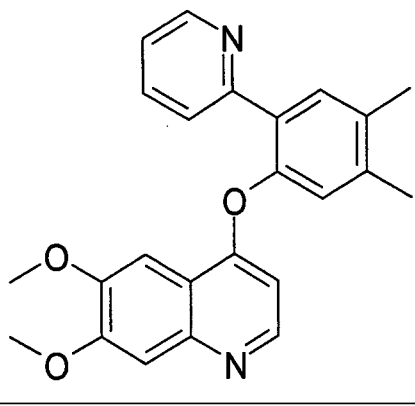
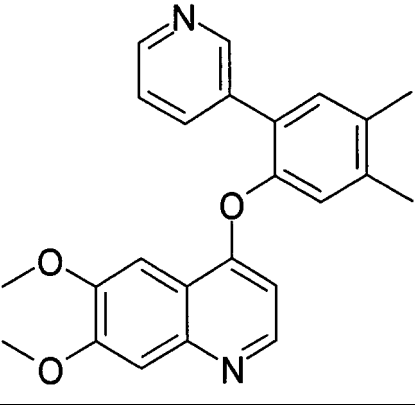
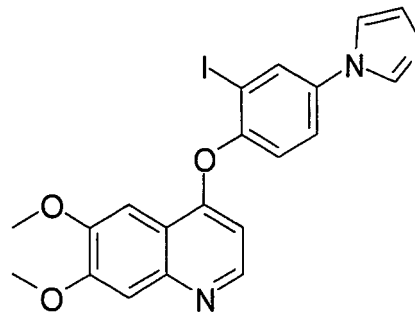
Compound	Molecular structure	TGFβ inhibition rate, %	
		10 μM	3 μM
r 161		83	25
r 162		54	5
r163		67	3

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Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 164		98	54	
r165		89	38	
r 166		67	24	
r167		100	98	

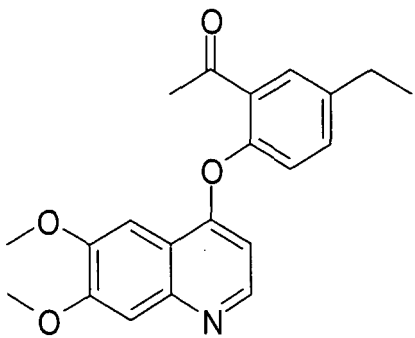
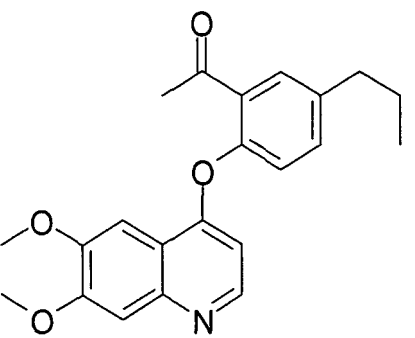
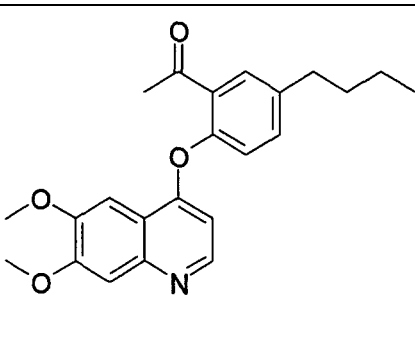
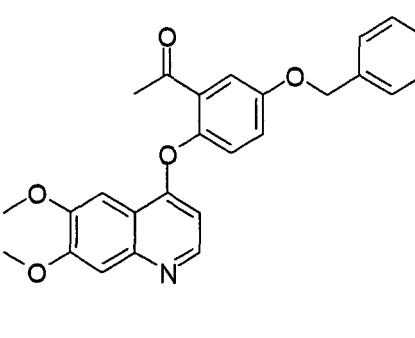
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r168		74	22	
r 169		100	99	
r170		100	76	
r 171		76	11	

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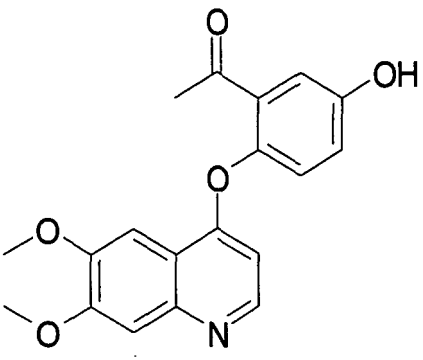
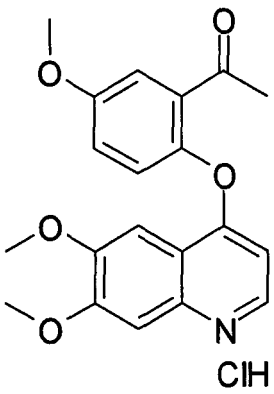
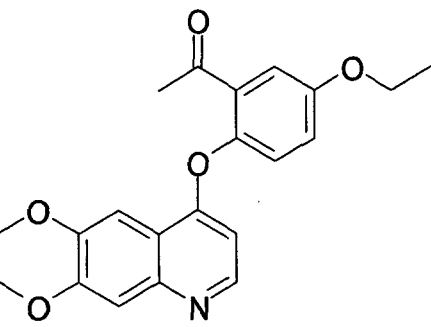
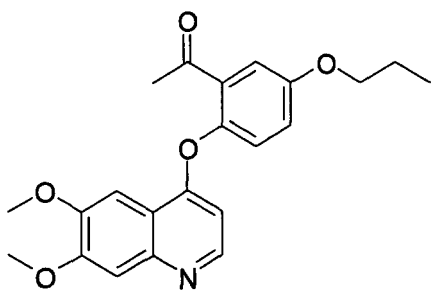
(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r172		99	82	
r 173		100	83	
r 174		96	57	
r175		60	13	

55

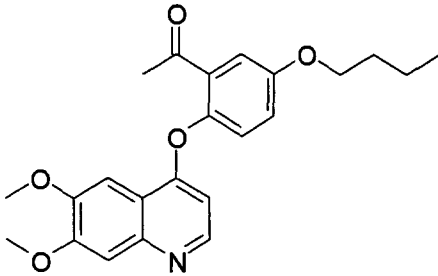
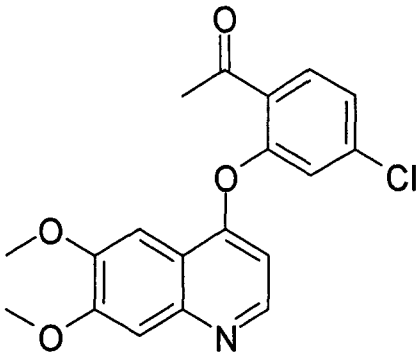
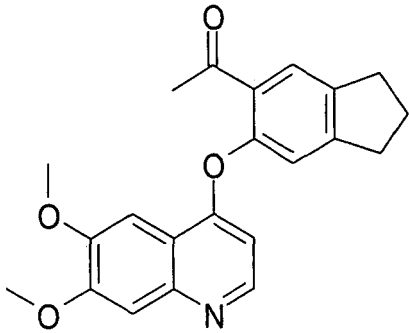
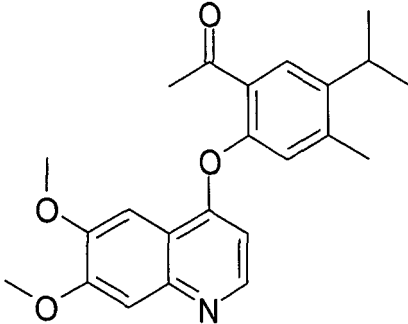
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r176		67	32	
r177		100	94	
r178		97	66	
r 179		68	18	

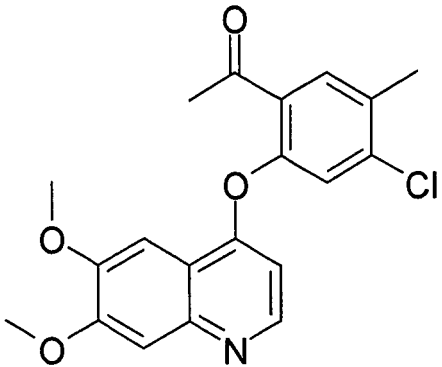
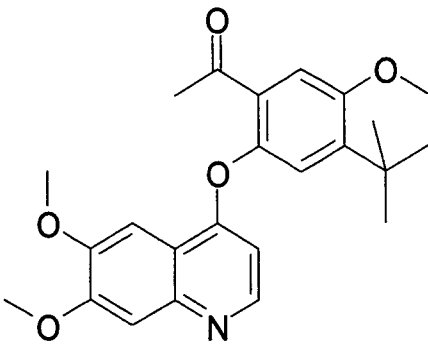
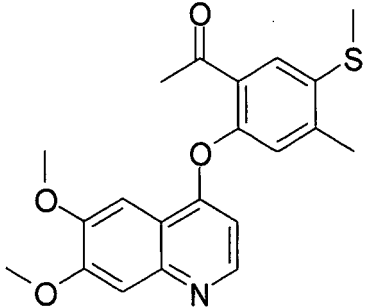
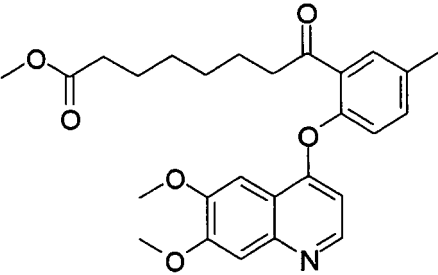
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r180		55	-2	
r181		82	42	
r182		96	57	
r183		100	82	

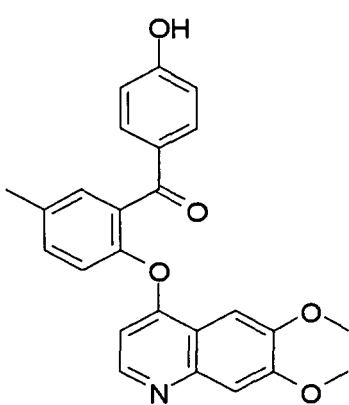
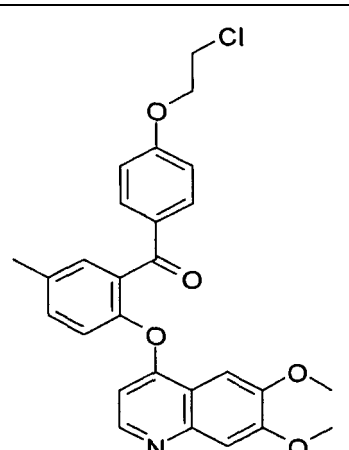
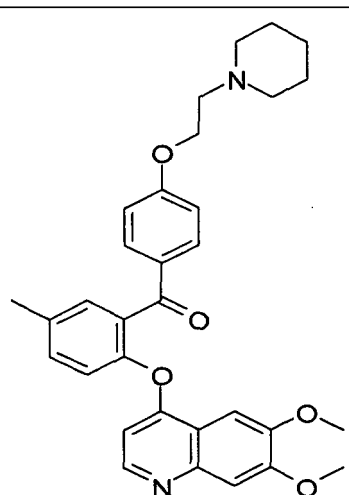
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 184		100	100	
r 185		59	11	
r 186		100	76	
r 187		91	35	

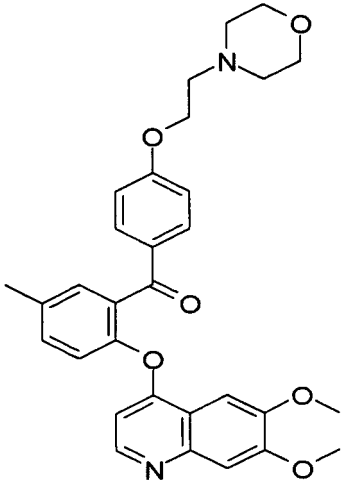
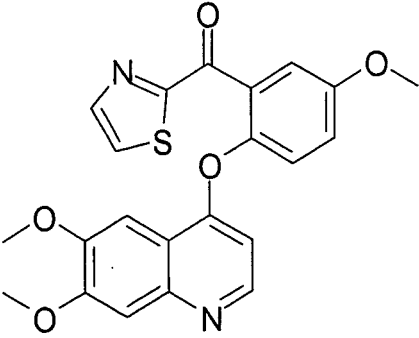
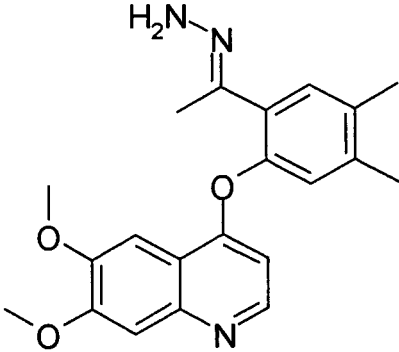
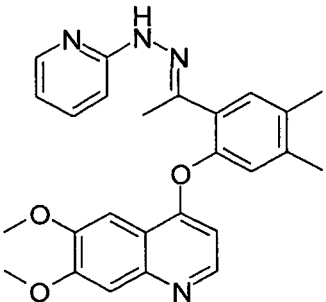
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 188		100	80	
r 189		100	86	
r 190		86	30	

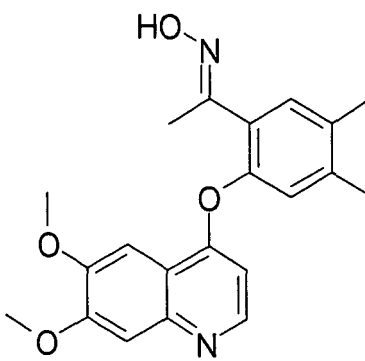
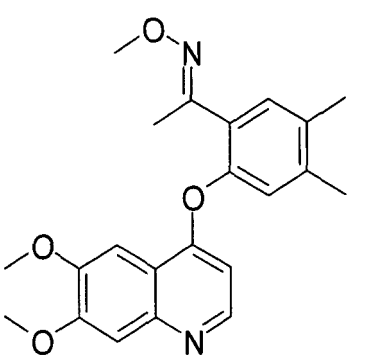
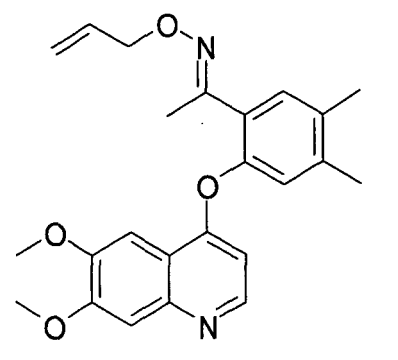
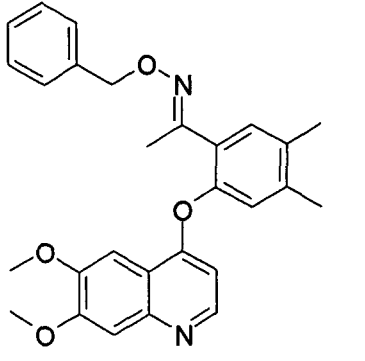
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 191		93	39	
r 192		99	79	
r193		99	74	
r 194		94	47	

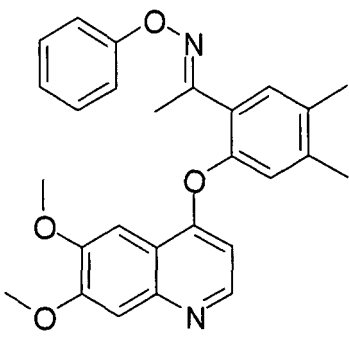
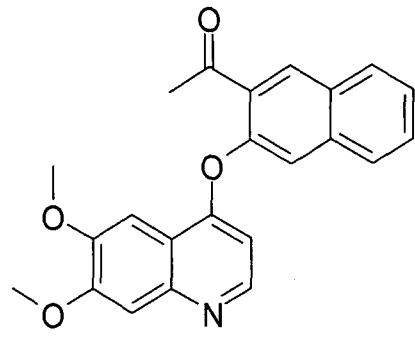
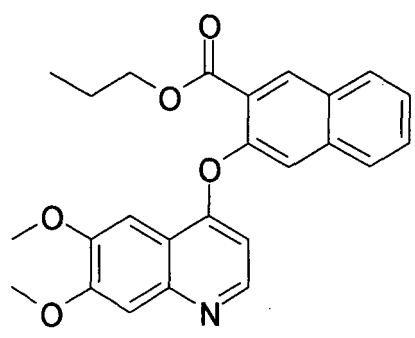
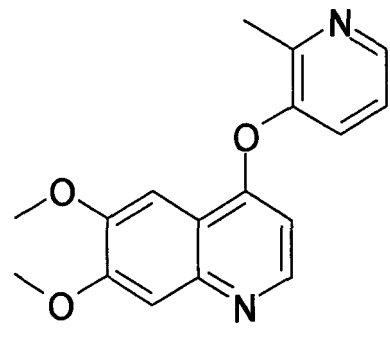
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 195		100	99	
r196		83	41	
r 197		88	40	
r198		80	32	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 199		59	14	
r 200		100	94	
r 201		100	79	
r 202		54	20	

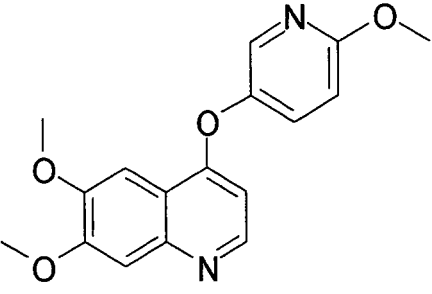
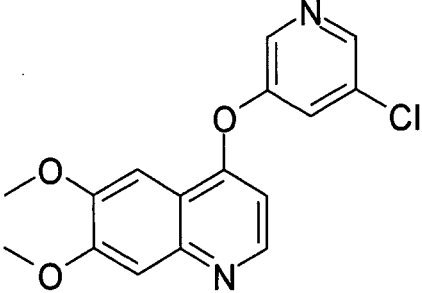
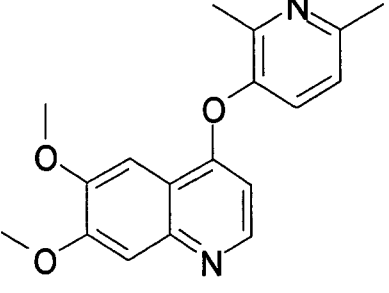
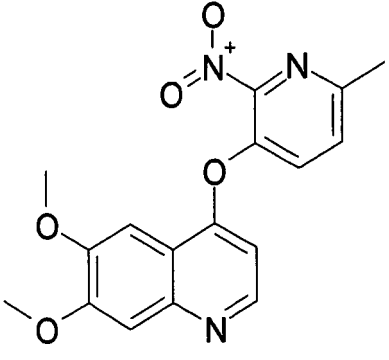
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 203	 <chem>COC1=CC=C2C(=C1)N=CN=C2OC3=CC=CC(=N3)Br</chem>	52	19	
r 204	 <chem>COC1=CC=C2C(=C1)N=CN=C2OC3=CC=CC(=N3)OC4CCCC4</chem>	77	14	
r 205	 <chem>COC1=CC=C2C(=C1)N=CN=C2OC3=CC=CC(=N3)F</chem>	57	26	
r 206	 <chem>COC1=CC=C2C(=C1)N=CN=C2OC3=CC=CC(=N3)Cl</chem>	94	69	

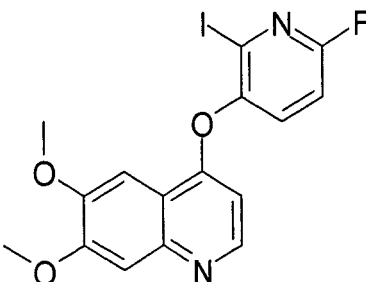
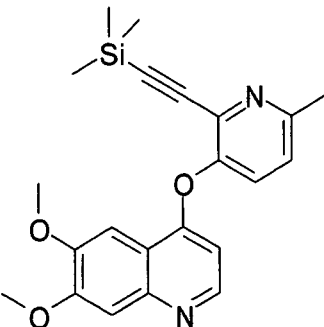
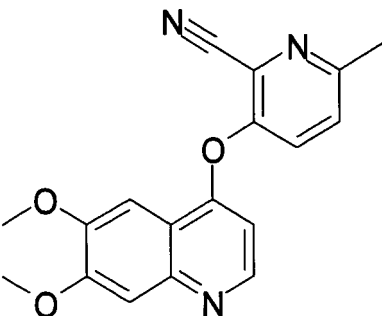
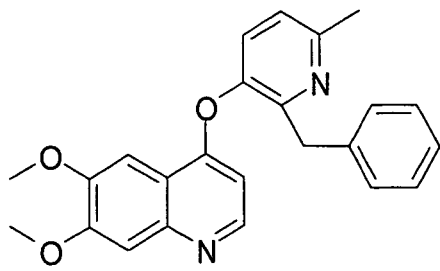
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 207		99	77	
r 208		73	18	
r 209		100	99	
r 210		80	45	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 211		100	87	
r 212		100	94	
r 213		65	28	
r 214		100	99	

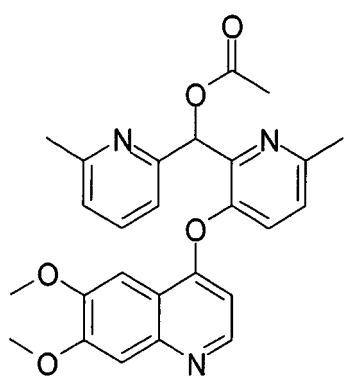
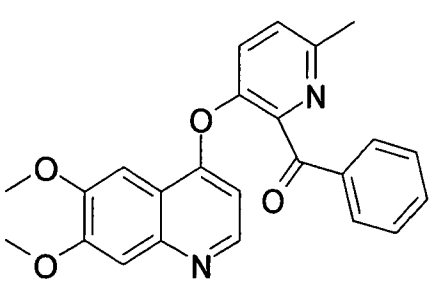
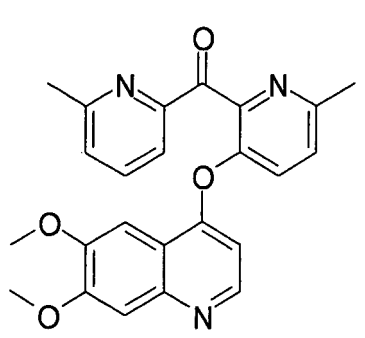
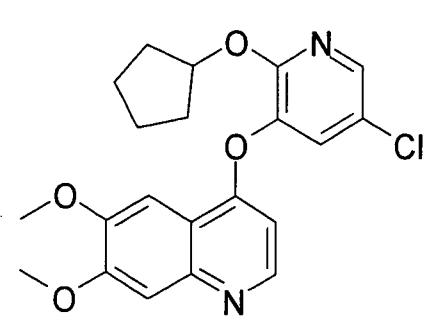
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 215		99	72	
r 216		73	22	
r 217		100	91	
r 218		56	21	

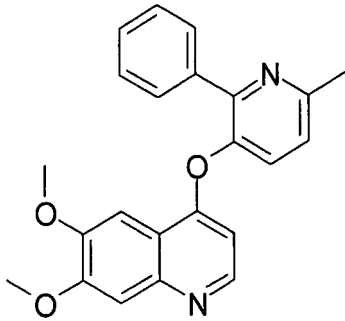
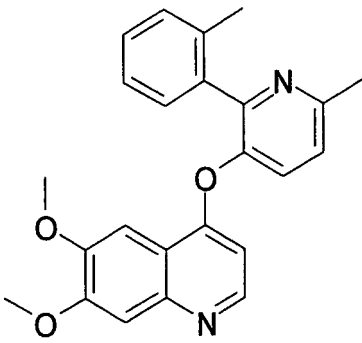
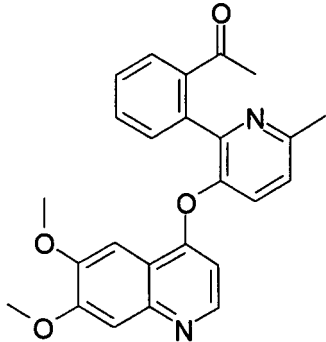
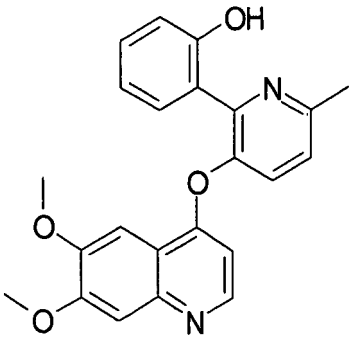
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 219		67	20	
r 220		100	99	
r 221		98	71	
r 222		100	44	

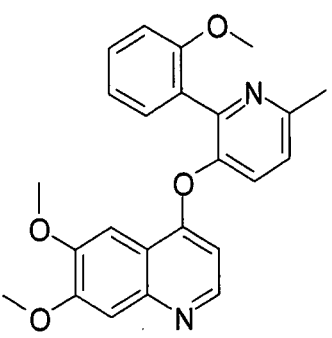
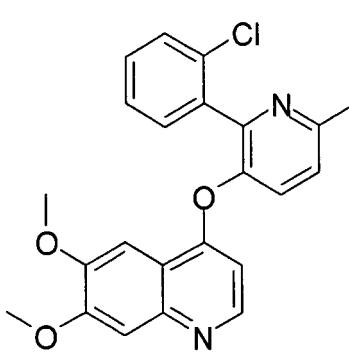
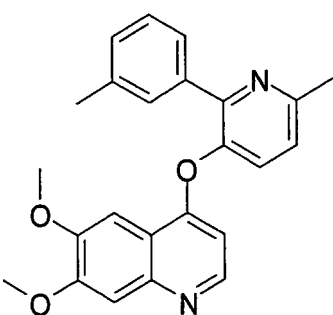
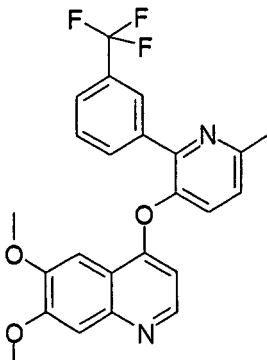
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 223		100	99	
r 224		96	69	
r 225		78	39	
r 226		96	60	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 227		87	50	
r 228		100	88	
r 229		100	99	
r 230		97	60	

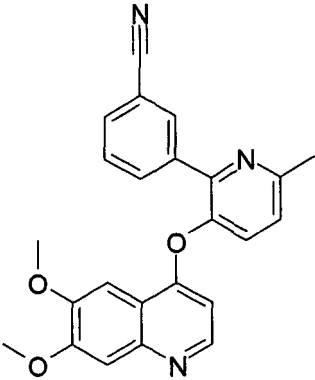
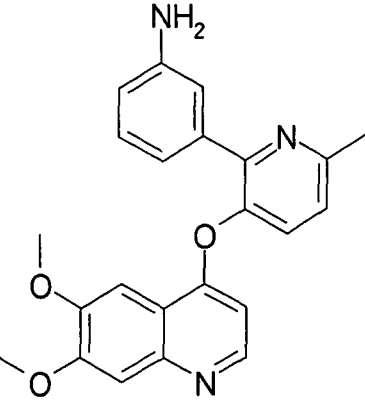
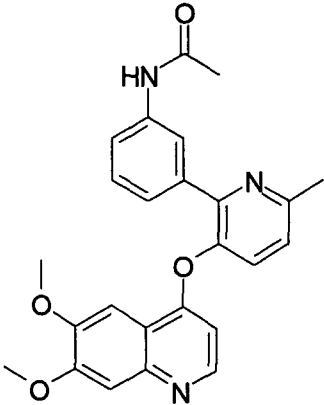
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 231		100	100	
r 232		79	66	
r 233		100	98	

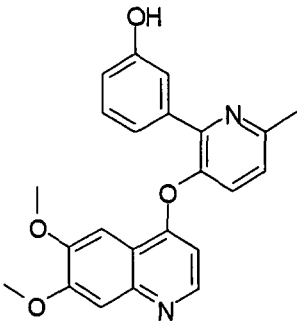
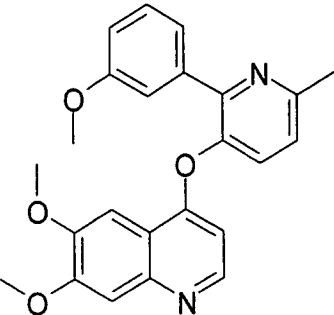
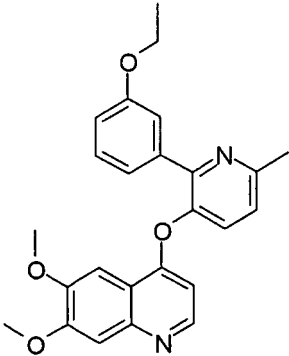
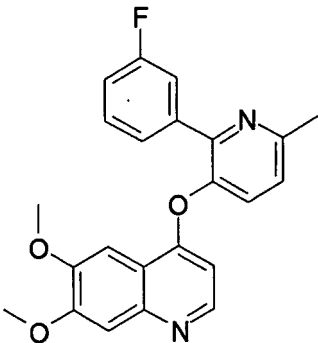
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 234		100	87	
r 235		100	100	
r 236		100	90	

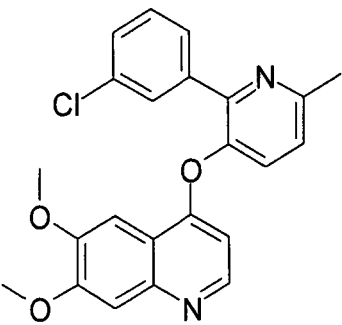
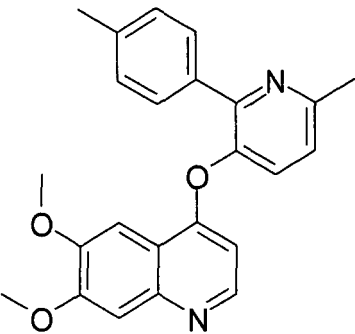
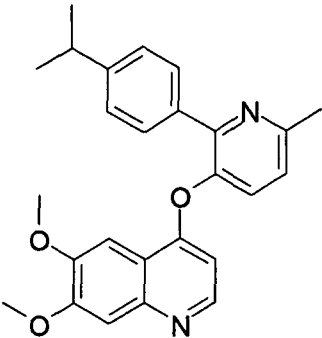
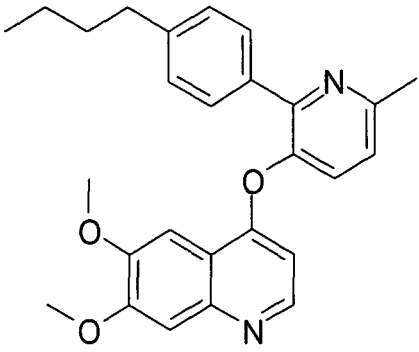
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 237		100	100	
r 238		100	92	
r 239		100	83	
r 240		100	100	

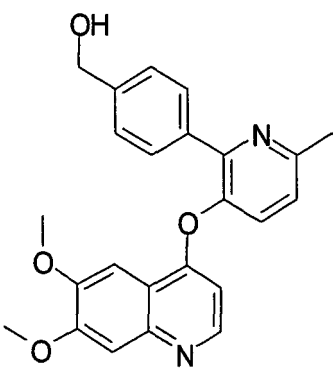
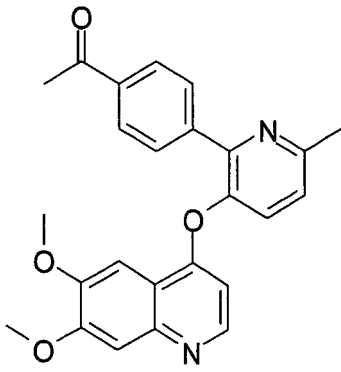
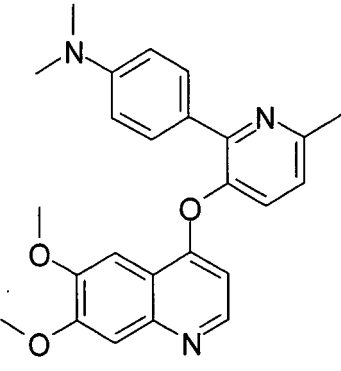
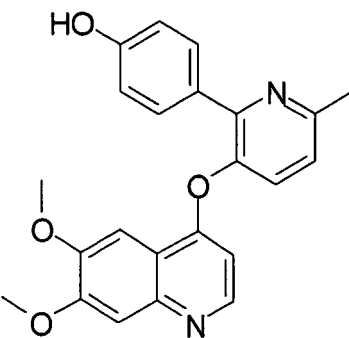
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 241		100	96	
r 242		99	68	
r 243		62	-7	
r 244		63	-3	

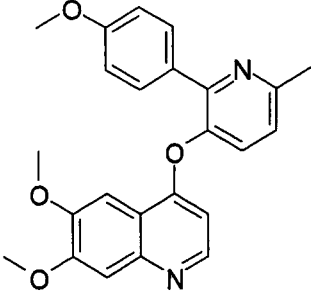
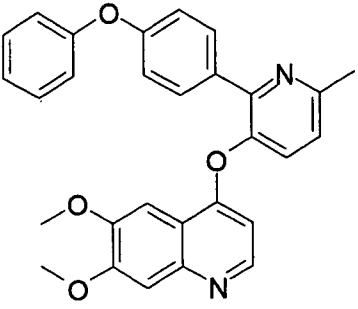
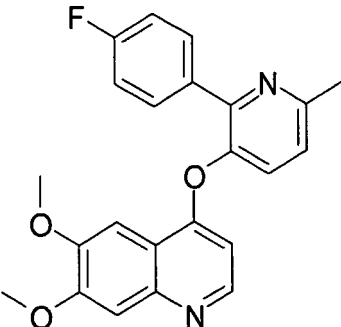
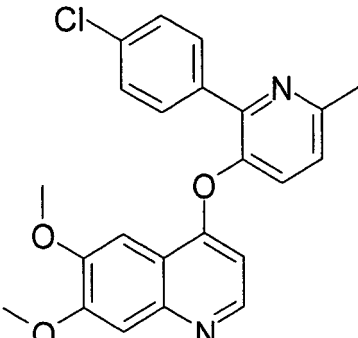
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 245		99	80	
r 246		93	64	
r 247		100	93	
r 248		100	99	

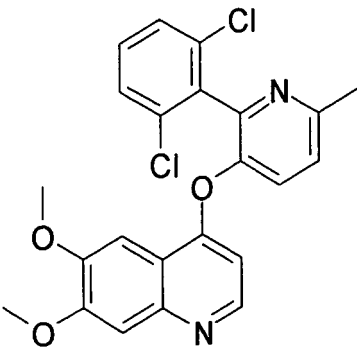
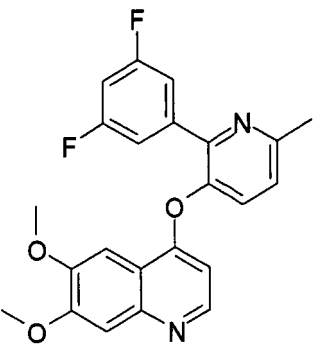
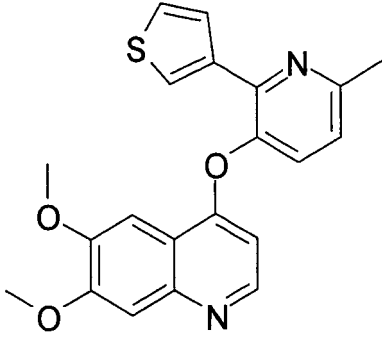
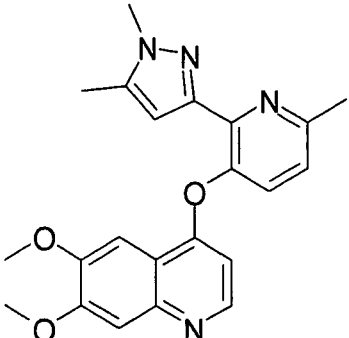
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 249		98	52	
r 250		81	34	
r 251		100	84	
r 252		78	16	

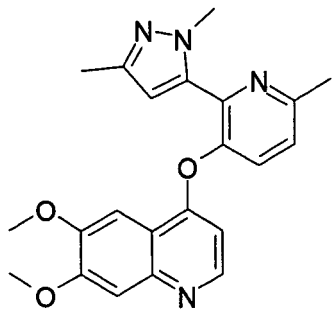
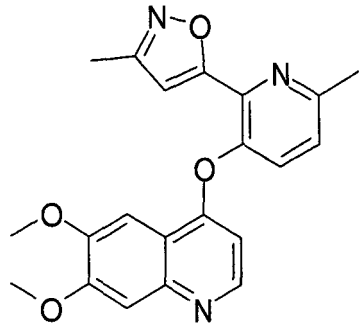
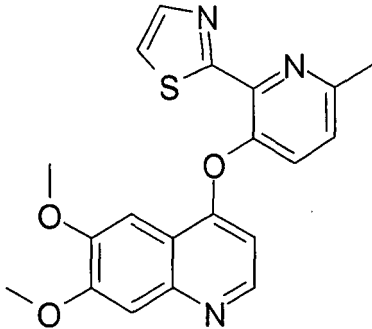
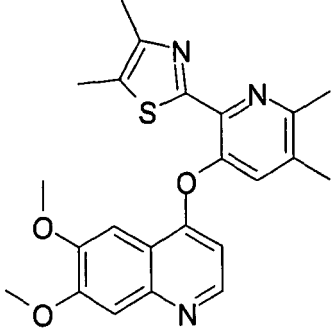
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 253		97	68	
r 254		100	100	
r 255		100	93	
r 256		100	98	

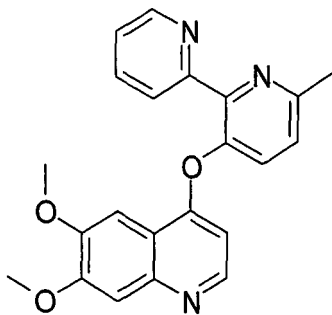
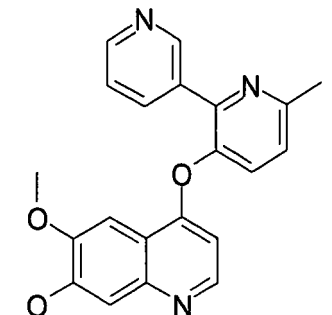
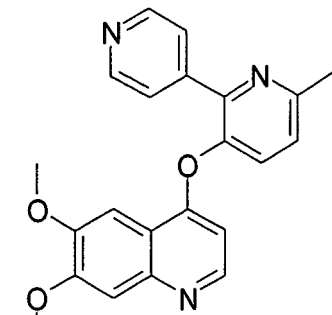
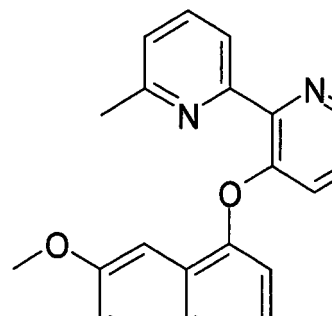
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 257		62	15	
r 258		100	99	
r 259				100
r 260		100	96	

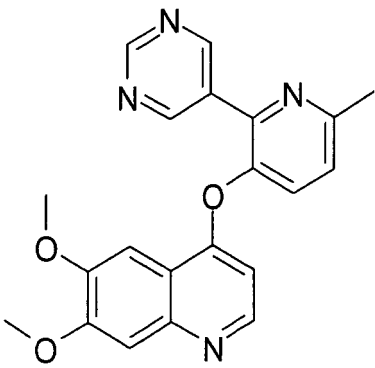
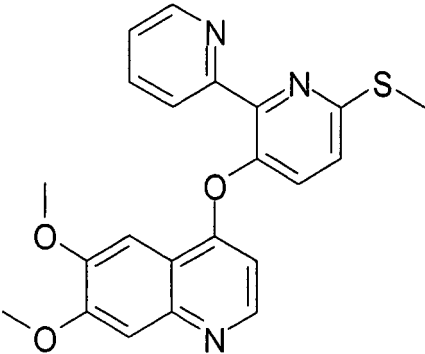
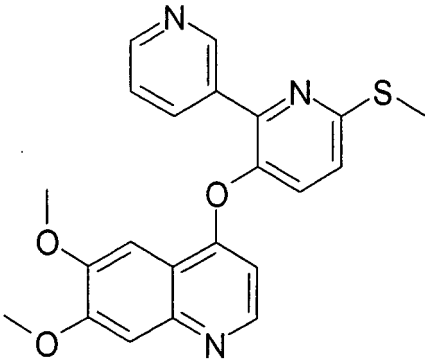
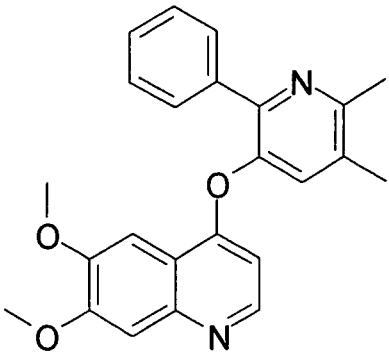
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 261		100	100	
r 262		100	91	
r 263		99	82	
r 264		100	88	

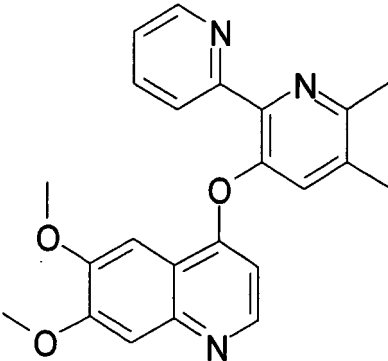
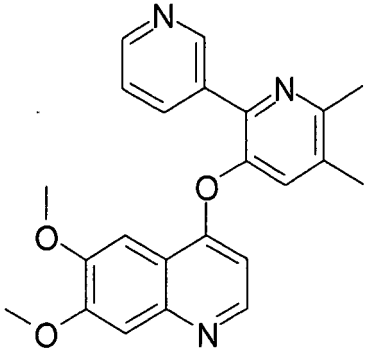
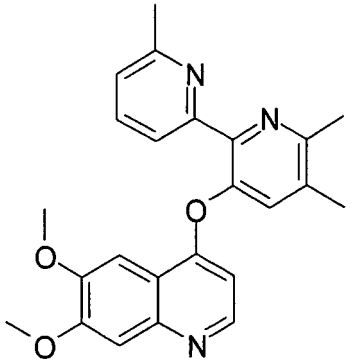
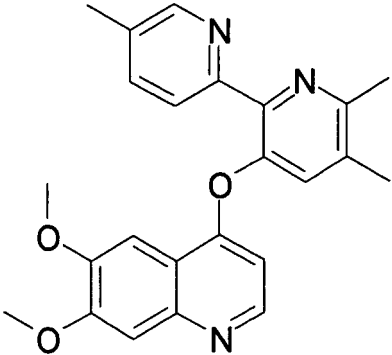
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 265		85	45	
r 266		100	92	
r 267		83	34	
r 268		100	100	

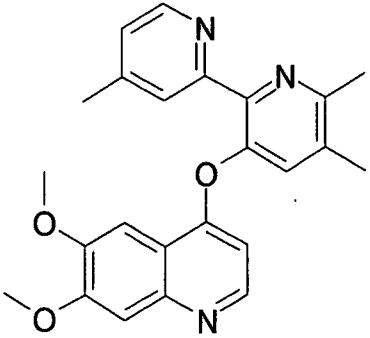
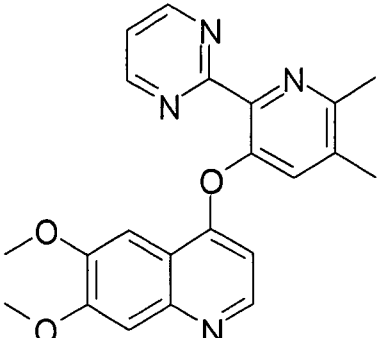
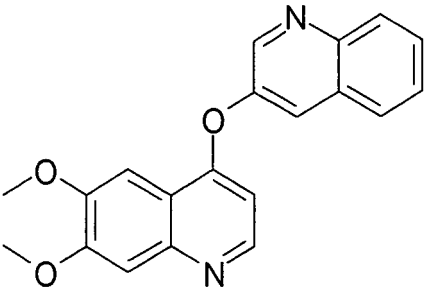
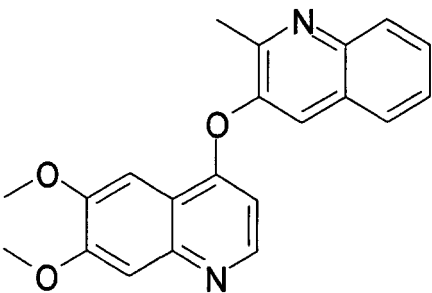
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 269				97
r 270			100	
r 271		100	94	
r 272		100	98	

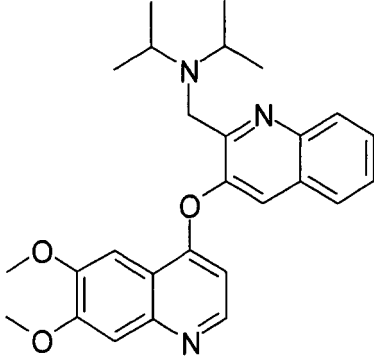
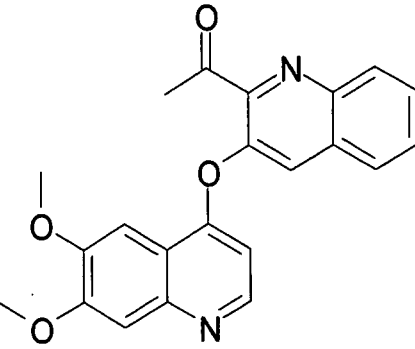
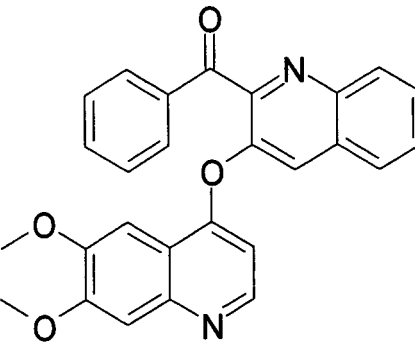
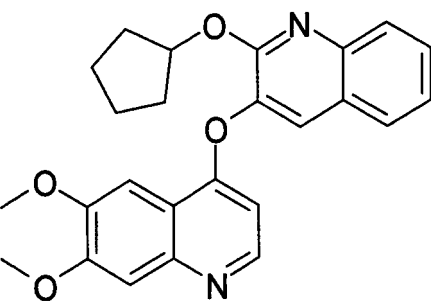
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 273		100	99	
r 274			97	
r 275		90	45	
r 276		100	89	

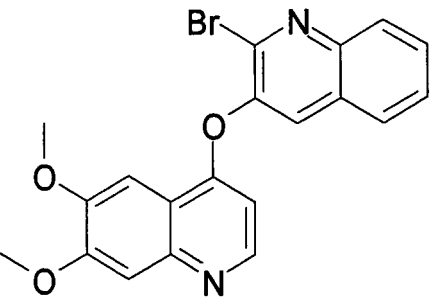
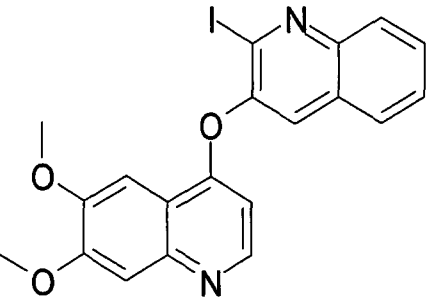
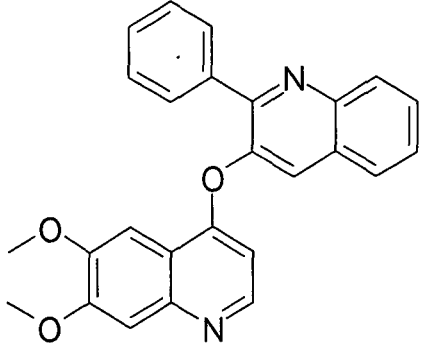
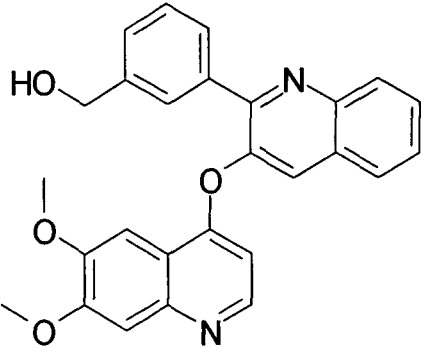
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 277		89	32	
r 278		99	90	
r 279		100	98	
r 280		88	45	

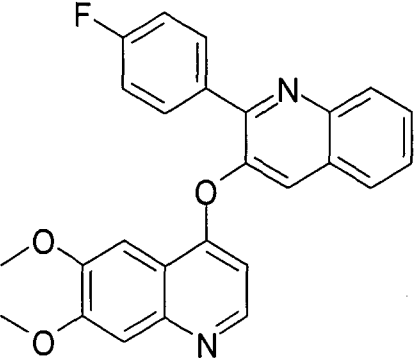
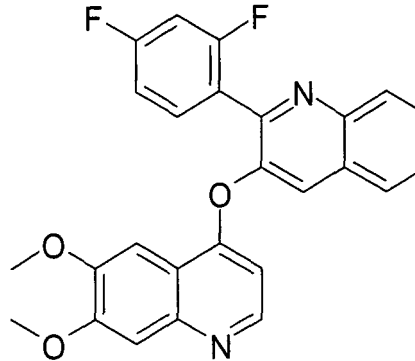
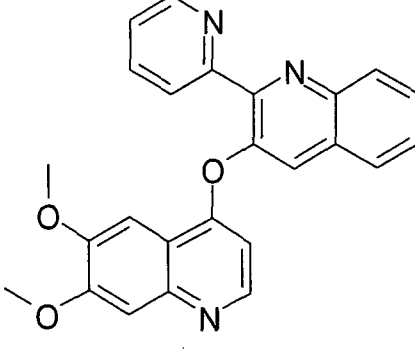
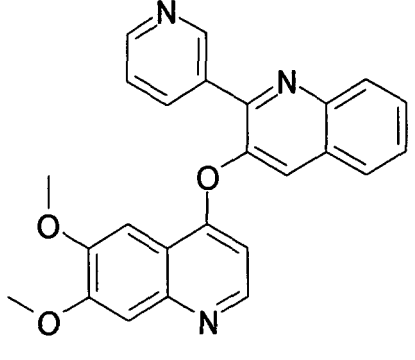
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 281		100	88	
r 282		100	96	
r 283		100	99	
r 284		100	96	

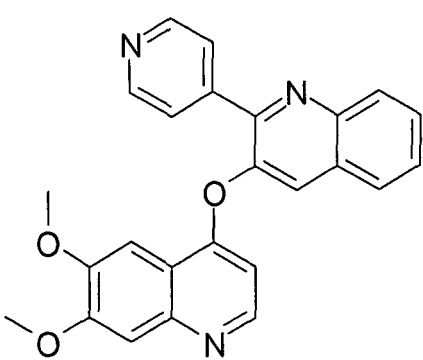
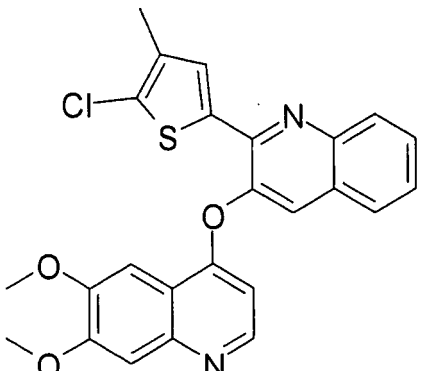
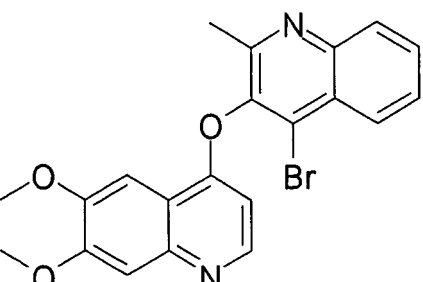
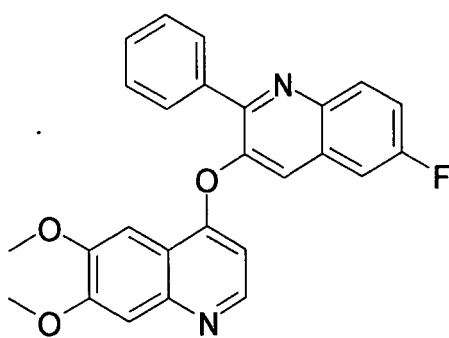
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 285		100	65	
r 286		100	93	
r 287		100	100	
r 288		100	94	

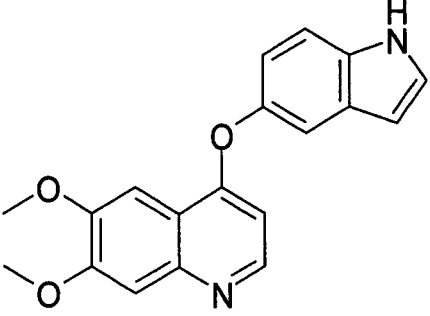
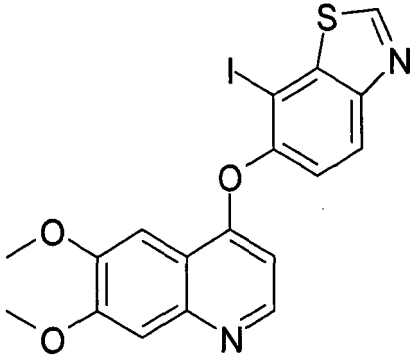
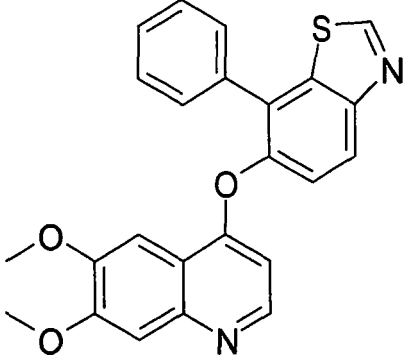
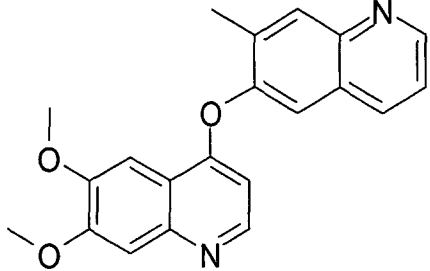
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 289		99	80	
r 290		57	18	
r 291		78	14	
r 292		100	86	

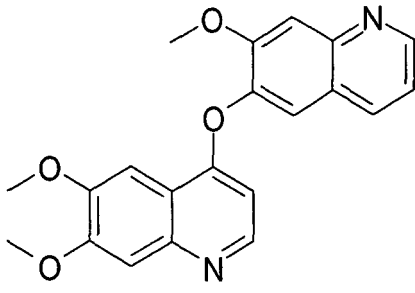
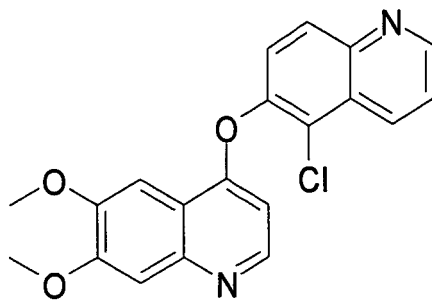
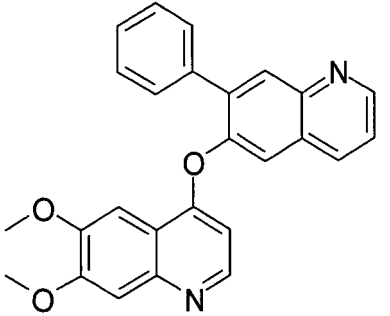
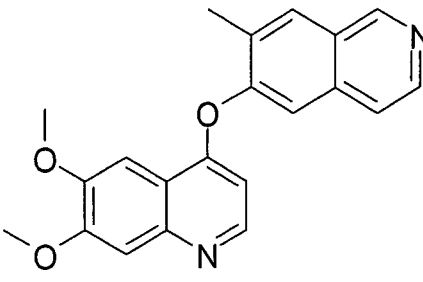
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(continued)

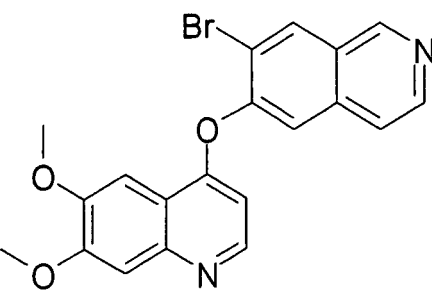
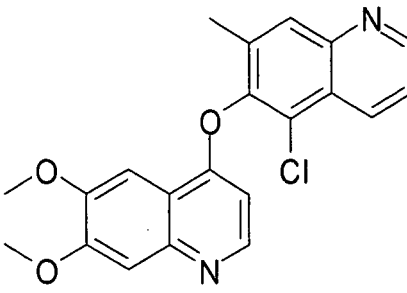
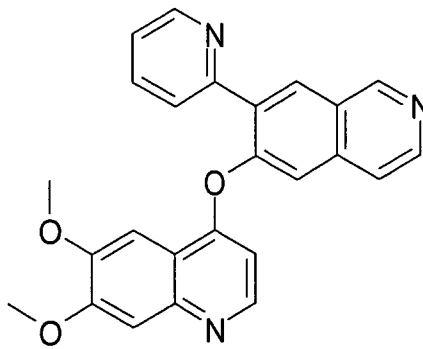
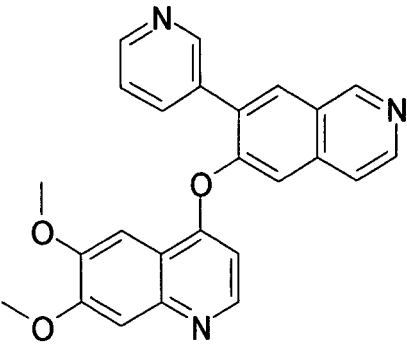
Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 293		95	65	
r 294		77	53	
r 295		96	47	
r 296		100	86	

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(continued)

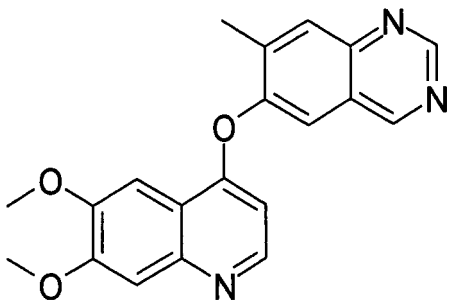
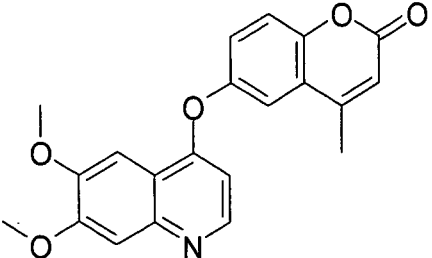
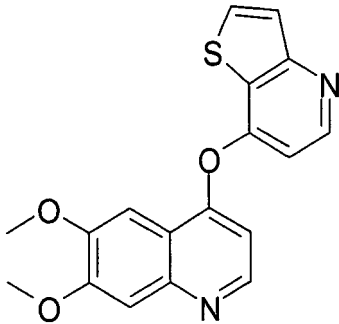
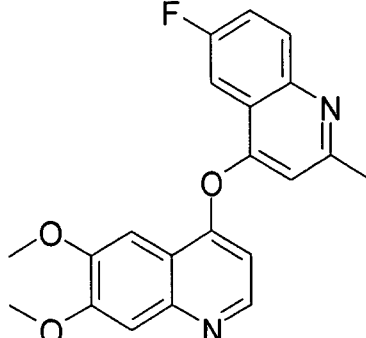
Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 297		94	61	
r 298		75	30	
r 299		100	99	
r 300		63	9	

(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 301		75	20	
r 302		90	30	
r 303			96	
r 304		64	26	

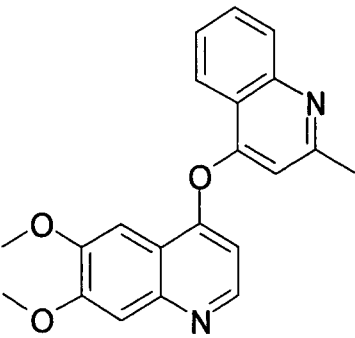
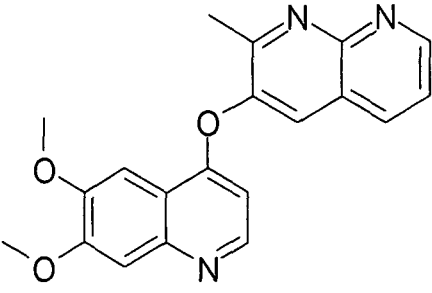
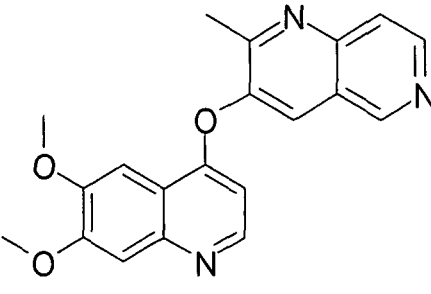
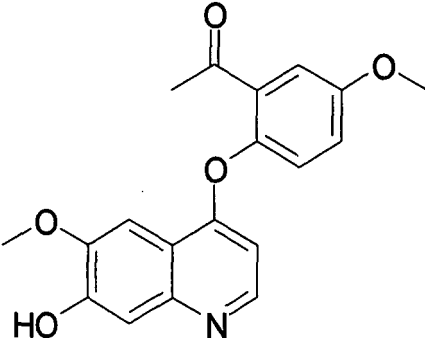
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 305		64	28	
r 306		53	20	
r 307		69	26	
r 308		56	21	

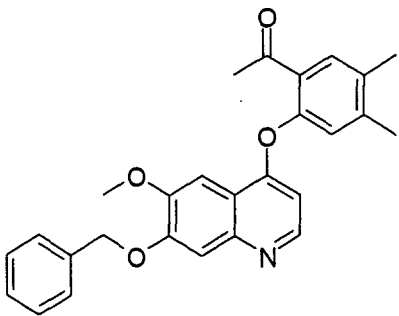
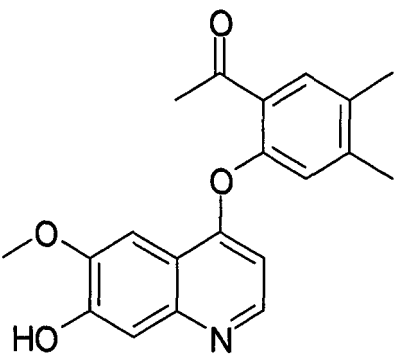
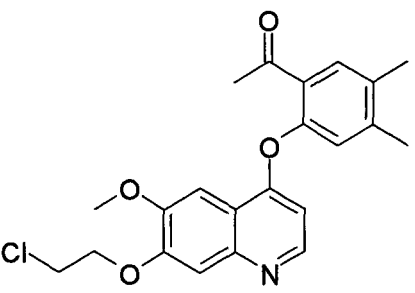
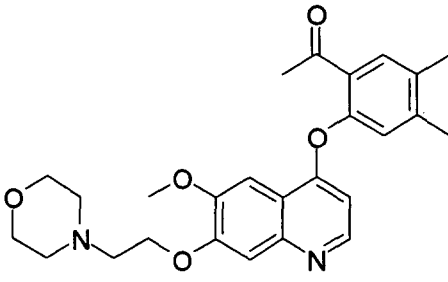
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 309		79	41	
r 310		97	72	
r 311		90	53	
r 312		76	50	

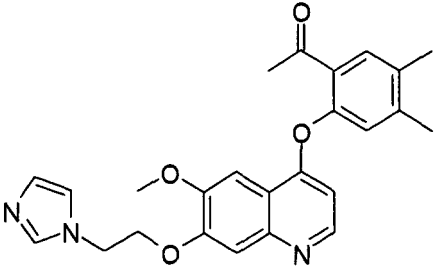
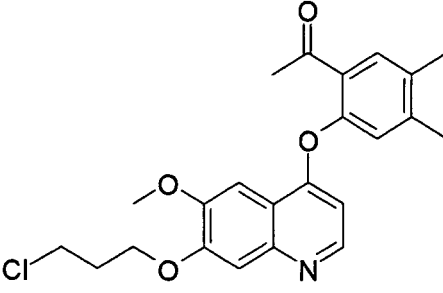
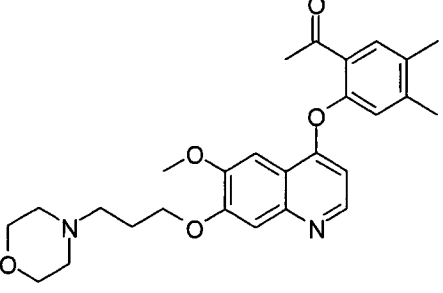
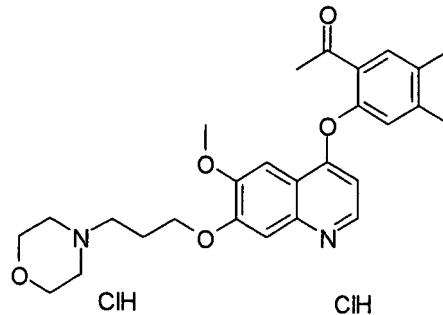
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 313		94	56	
r 314		89	50	
r 315		100	98	
r 316		100	99	

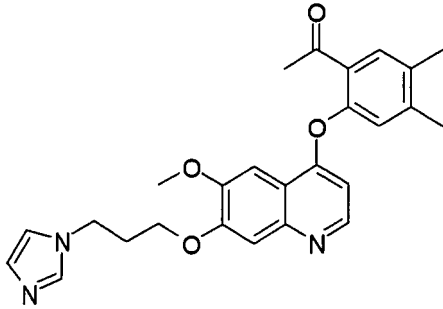
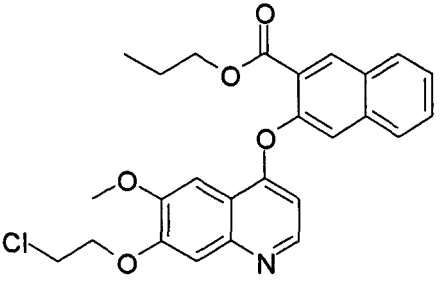
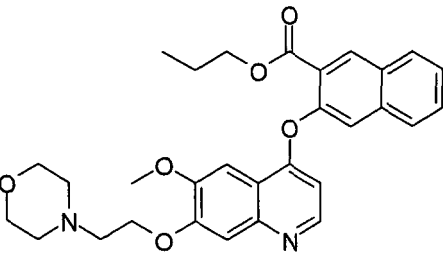
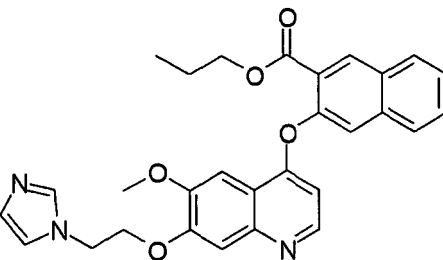
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 317		100	100	
r 318		100	82	
r 319		100	100	
r 320		100	100	

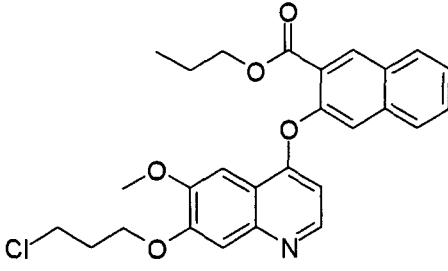
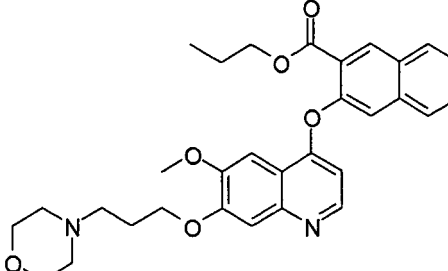
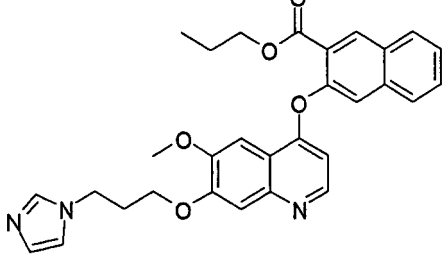
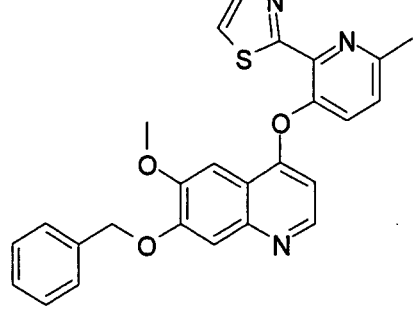
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 321		100	100	
r 322		88	50	
r 323		100	89	
r 324		100	86	

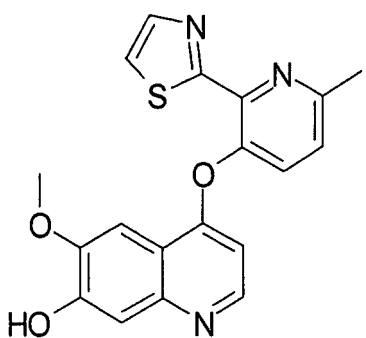
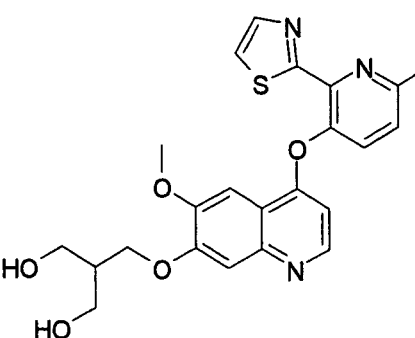
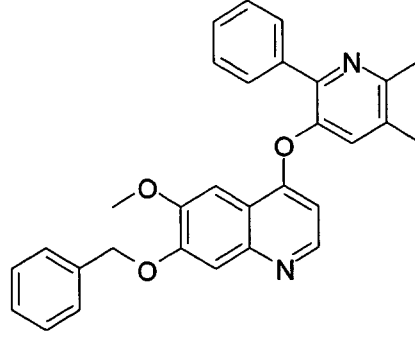
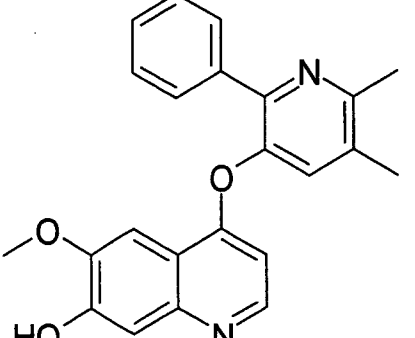
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 325		60	19	
r 326		100	83	
r 327		100	89	
r 328		100	100	

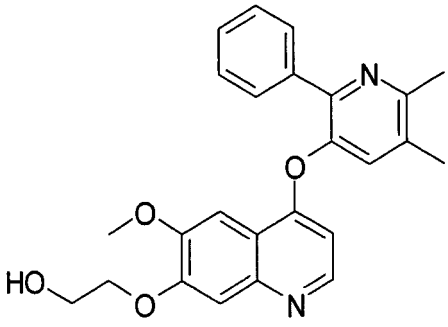
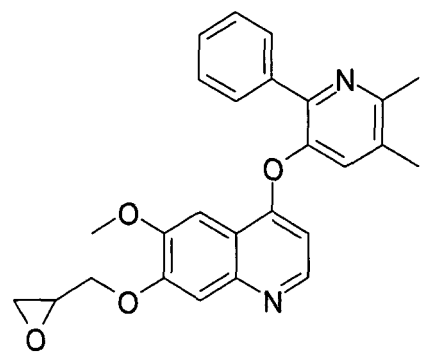
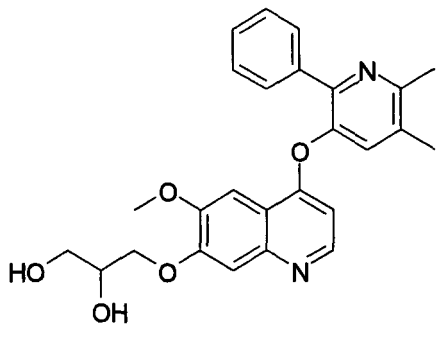
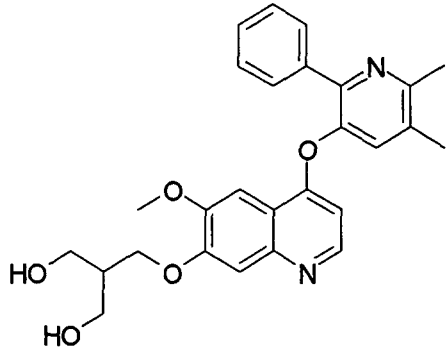
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 329		100	100	
r 330		100	100	
r 331		90	73	
r 332		100	97	

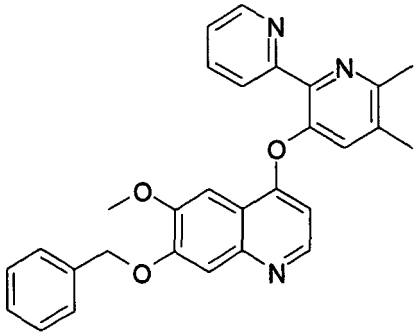
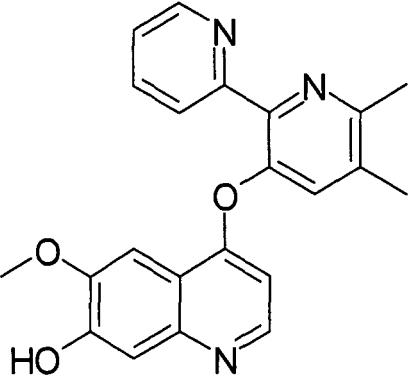
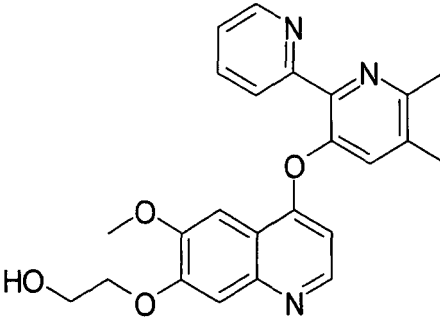
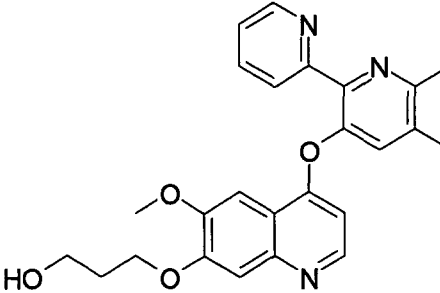
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 333			100	
r 334			99	
r 335			100	
r 336			100	

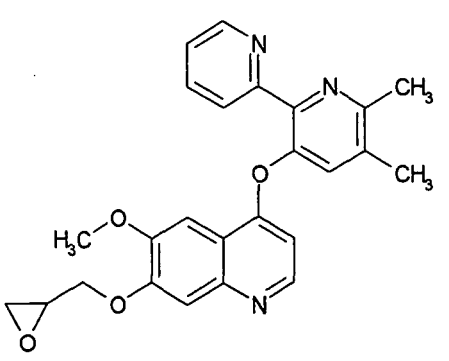
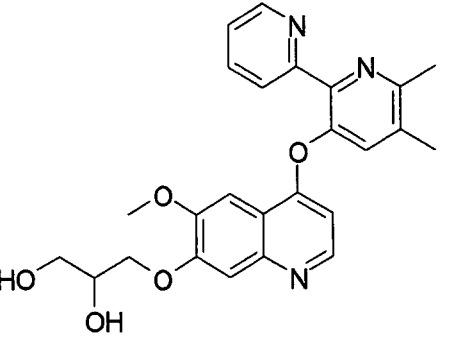
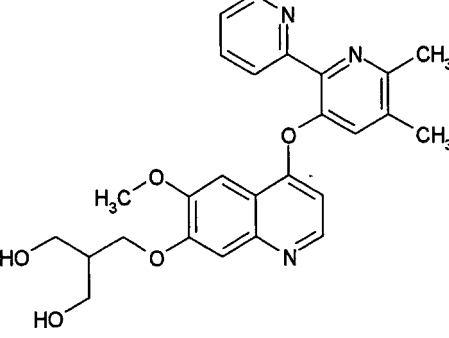
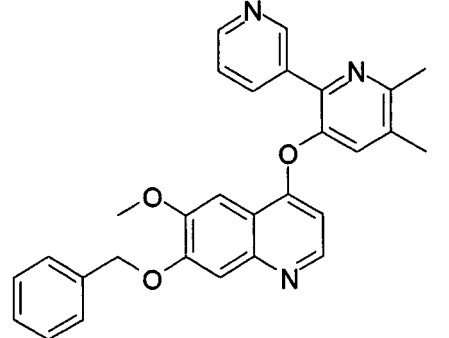
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 337			98	
r 338		100	92	
r 339			100	
r 340			99	

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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 341			99	
r 342			89	
r 343			93	
r 344			92	

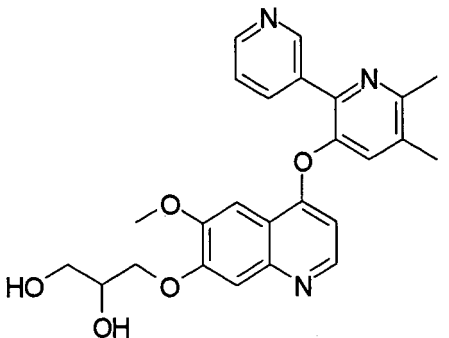
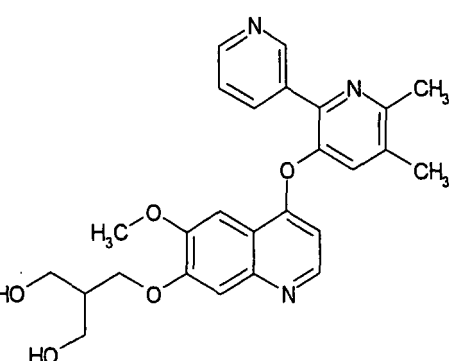
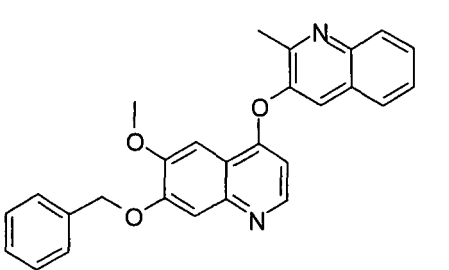
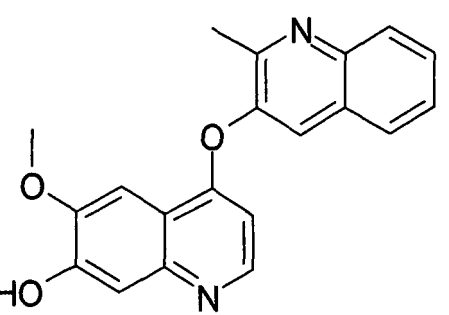
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 345		93	61	
r 346			99	
r 347			100	
r 348			76	

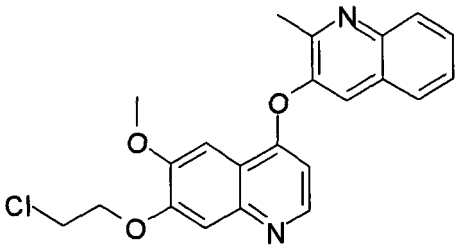
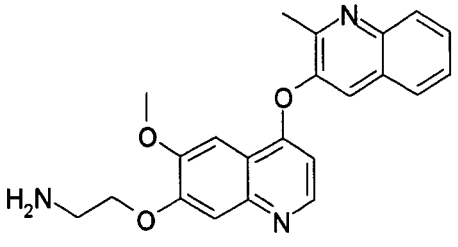
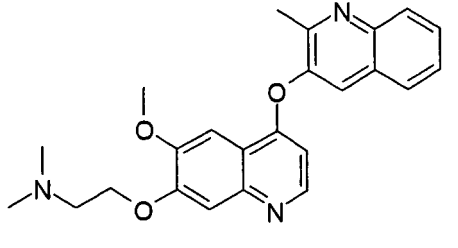
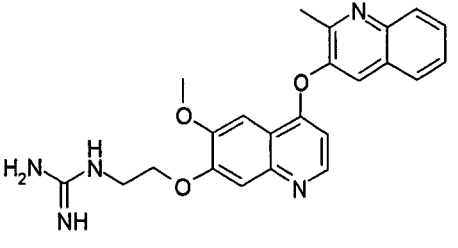
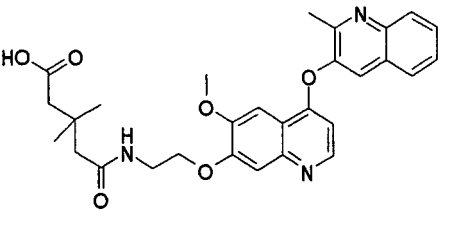
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 349			96	
r 350			96	
r 351		90	42	
r 352		68	14	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 353		86	54	
r 354		100	100	
r 355		100	100	
r 356		54	-2	
r 357		60	27	

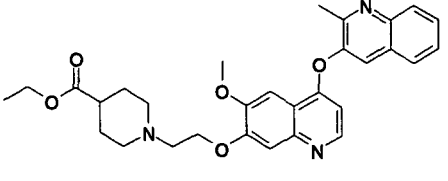
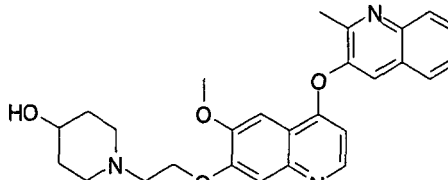
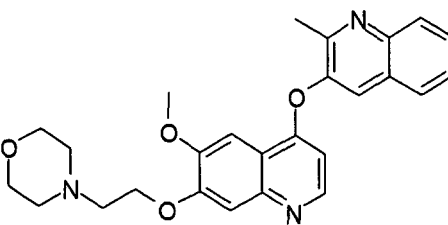
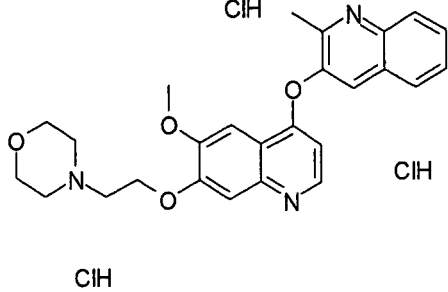
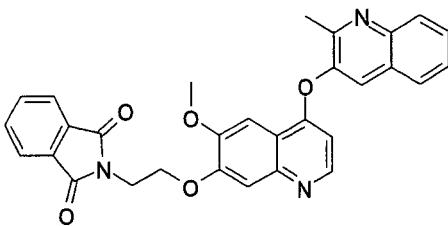
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 358		100	100	
r 359		100	100	
r 360		100	100	
r 361		100	96	
r 362		100	100	

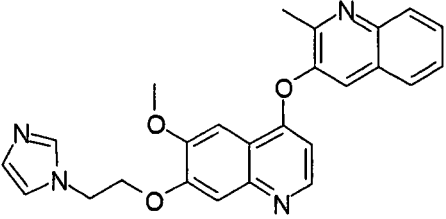
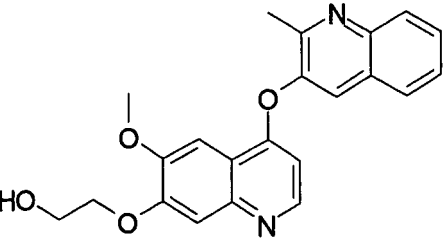
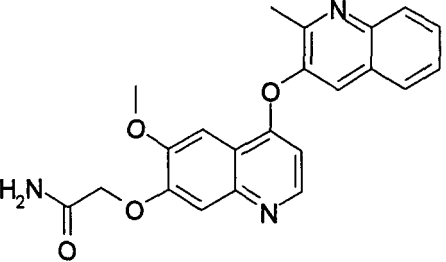
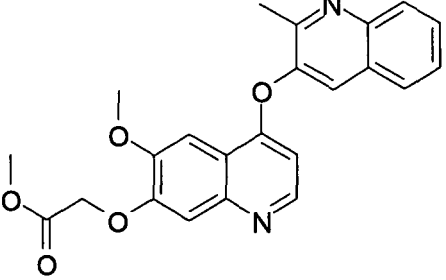
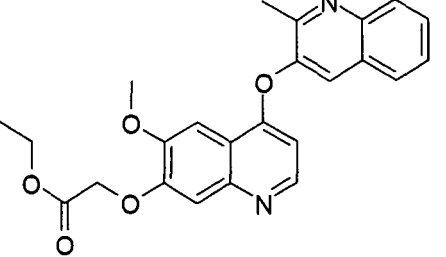
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 363		100	100	
r 364		100	100	
r 365		100	100	
r 366		100	100	
r 367		98	95	

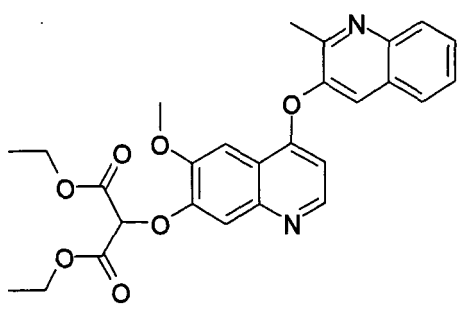
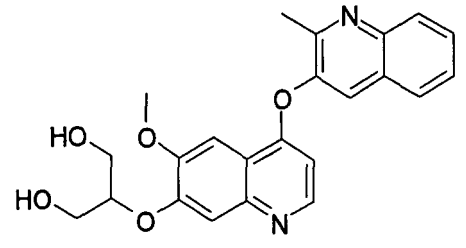
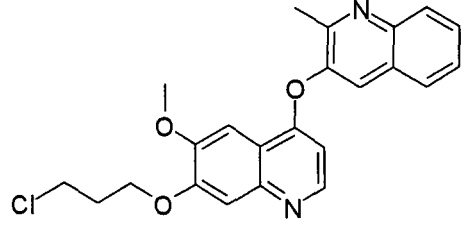
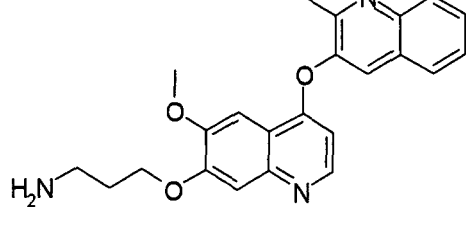
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 368		100	100	
r 369		100	99	
r 370		99	85	
r 371		90	28	
r 372		93	14	

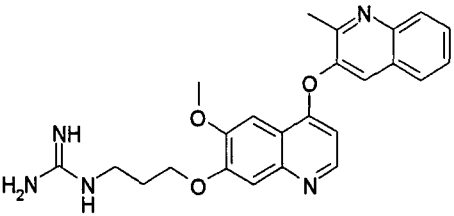
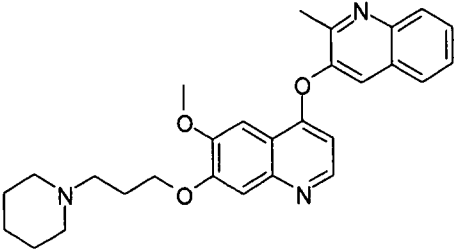
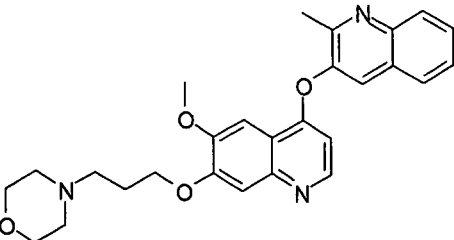
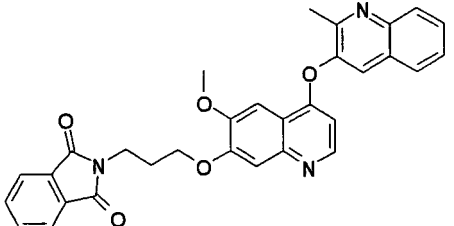
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 373		86	48	
r 374		79	26	
r 375		100	84	
r 376		100	100	

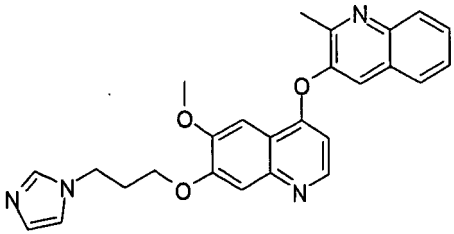
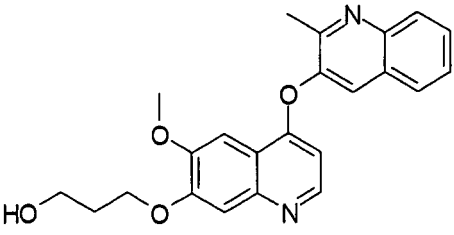
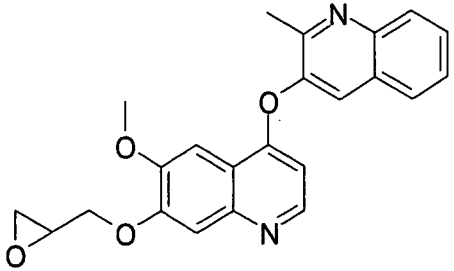
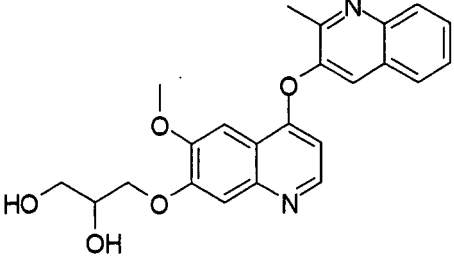
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 377		100	93	
r 378		100	100	
r 379		100	100	
r 380		89	50	

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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 381		100	100	
r 382		100	100	
r 383		100	97	
r 384		100	100	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 385		100	100	
r 386			99	
r 387		100	99	
r 388		100	88	

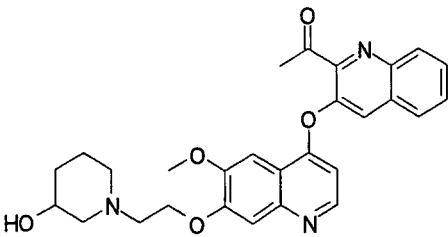
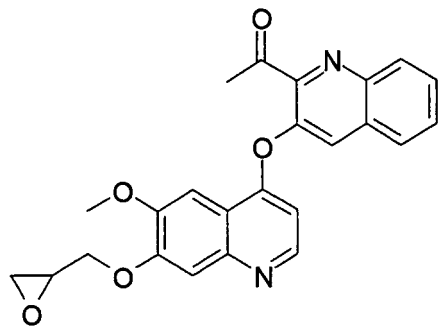
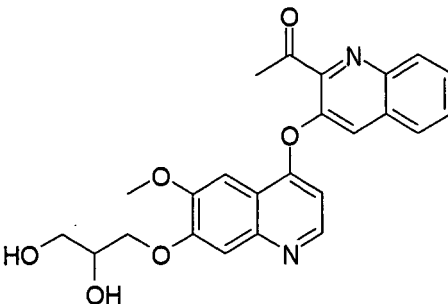
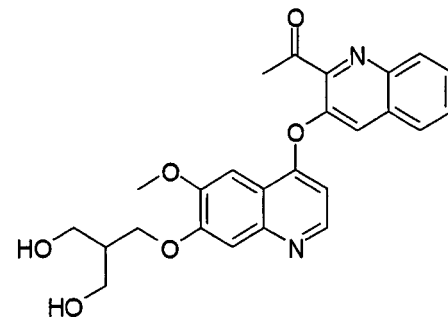
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 389		100	100	
r 390		64	16	
r 391		100	99	
r 392		100	93	

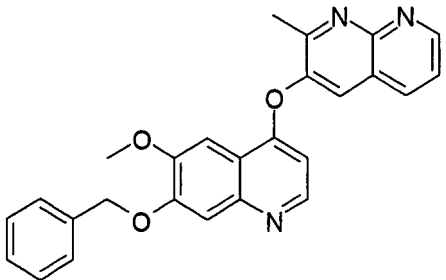
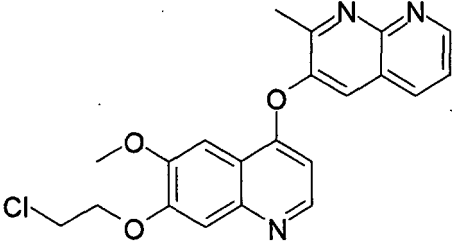
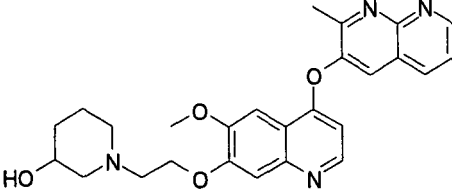
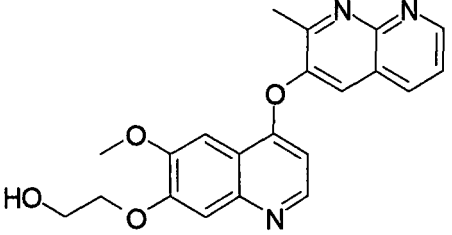
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 393			100	
r 394		100	83	
r 395		100	96	
r 396			96	

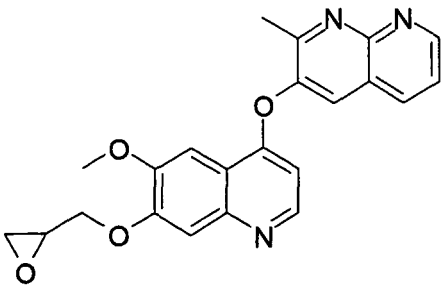
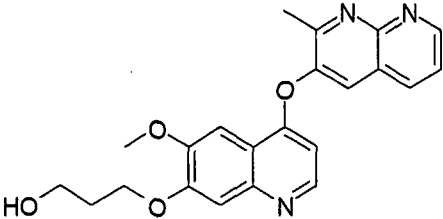
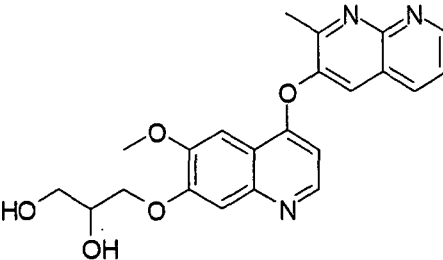
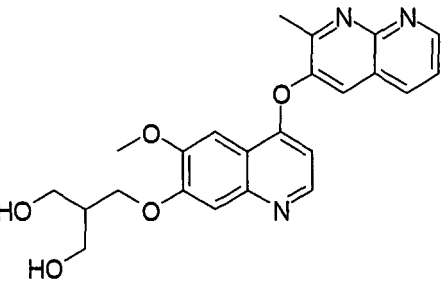
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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 397		100	71	
r 398		97	78	
r 399		100	99	
r 400		100	82	

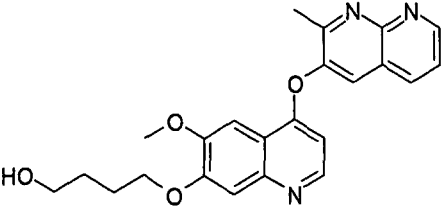
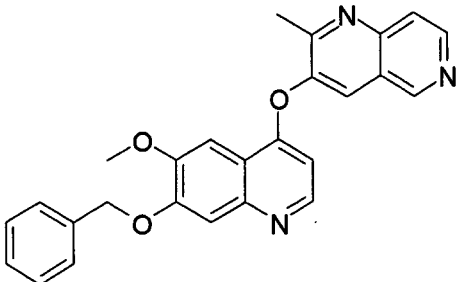
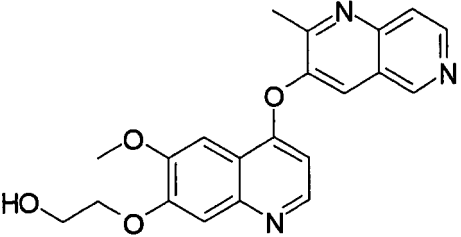
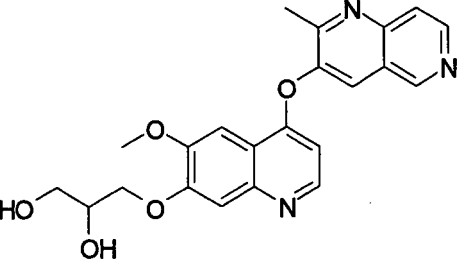
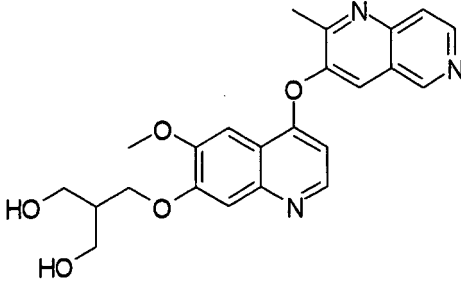
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 401		76	24	
r 402		100	90	
r 403		66	27	
r 404		72	29	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 405		100	92	
r 406		96	56	
r 407		97	71	
r 408		79	38	
r 409		88	41	

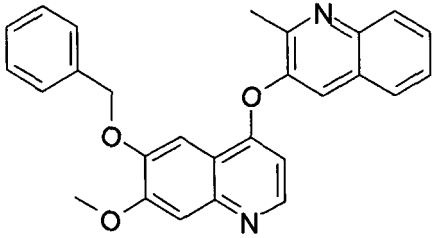
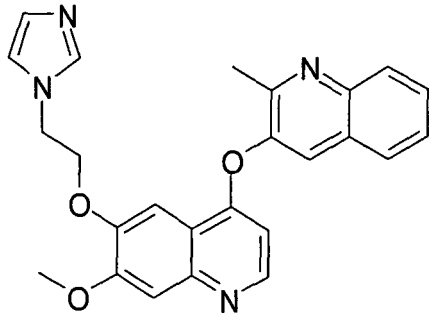
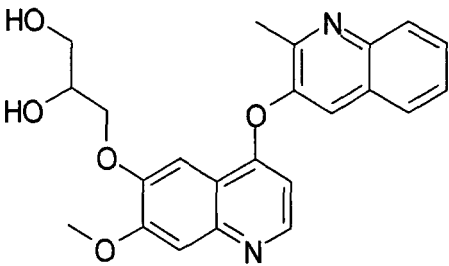
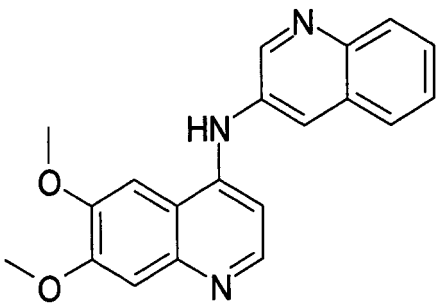
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 410		100	91	
r 411		85	50	
r 412		99	77	
r 413		76	31	
r 414		100	82	

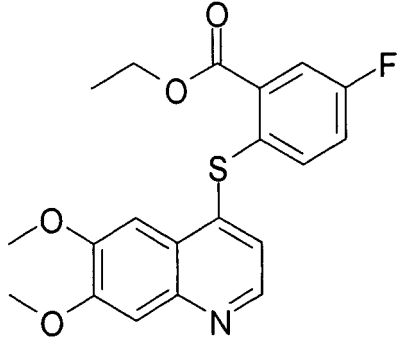
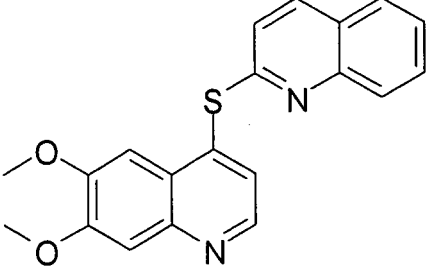
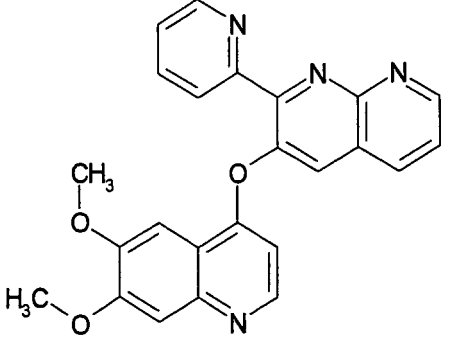
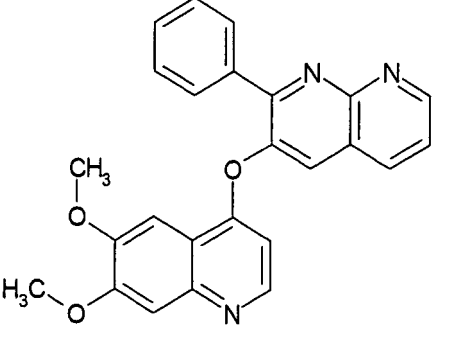
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 415		100	77	
r 416		100	92	
r 417		100	98	
r 418		73	46	

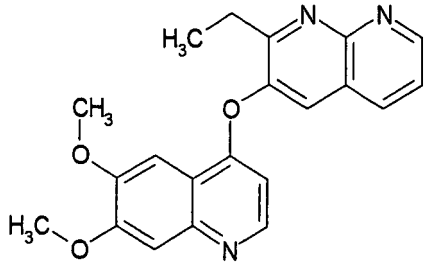
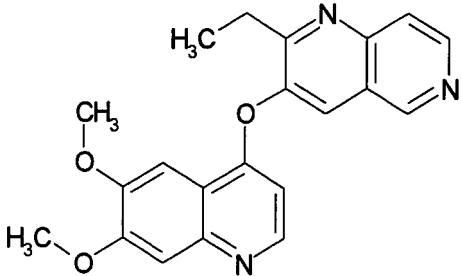
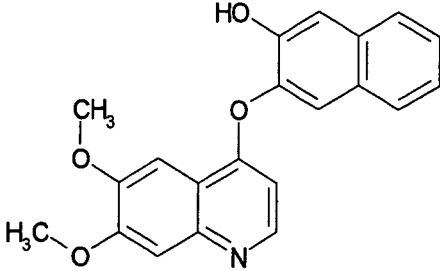
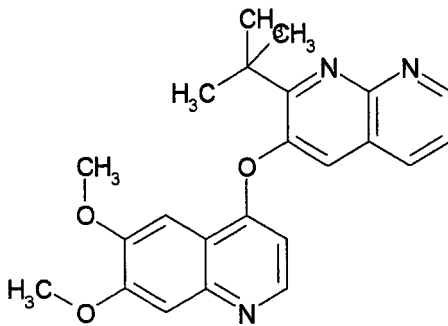
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 419		67	7	
r 420		62	2	
r 421		100	94	
r 422		100	100	

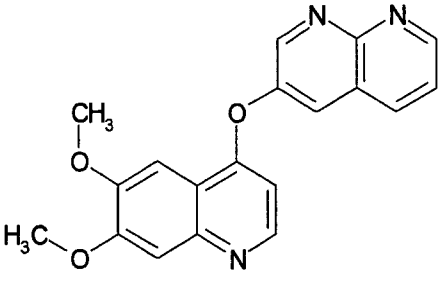
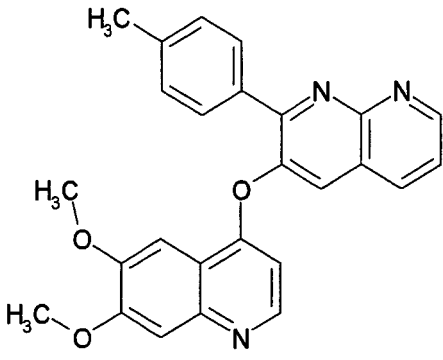
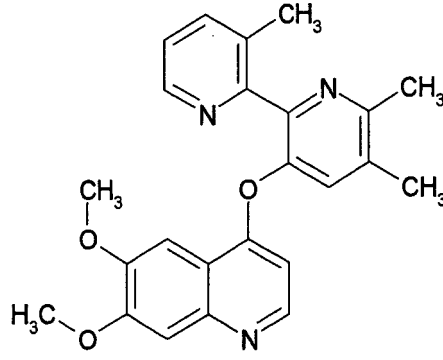
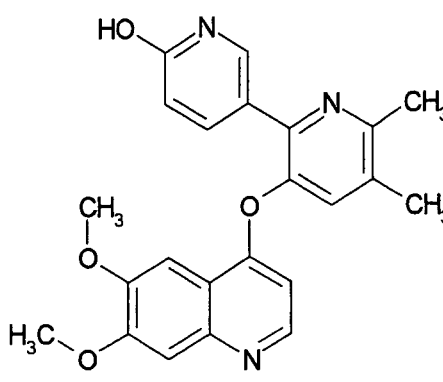
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 423		100	88	
r 424		79	28	
r 425		100	72	
r 426			100	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 427		80	44	
r 428			67	
r 429		94	52	
r 430		78	19	

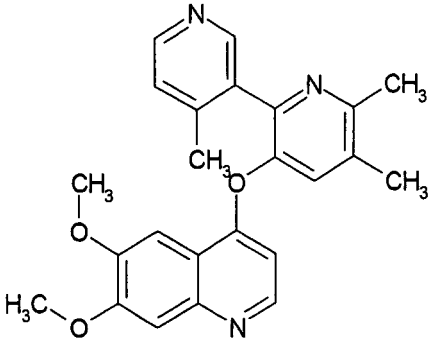
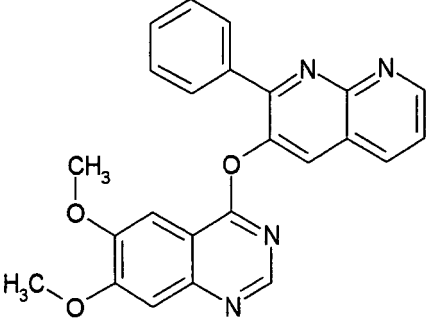
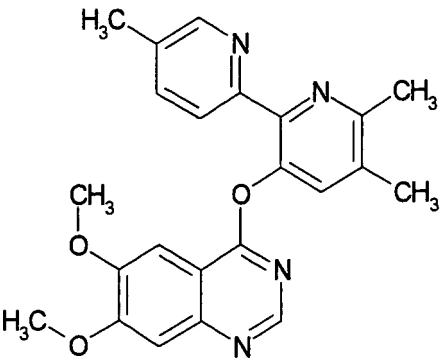
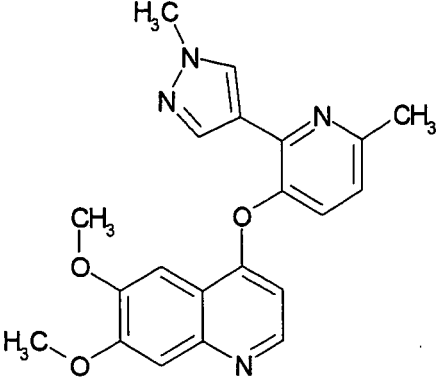
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 431		99	97	
r 432		100	99	
r 433		100	91	
r 434		100	100	

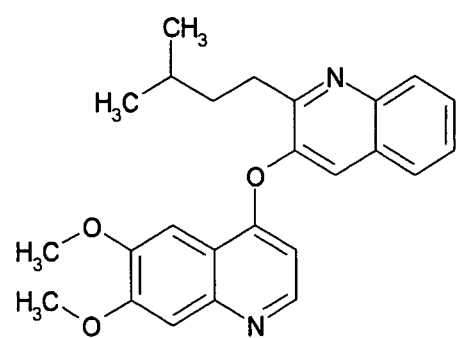
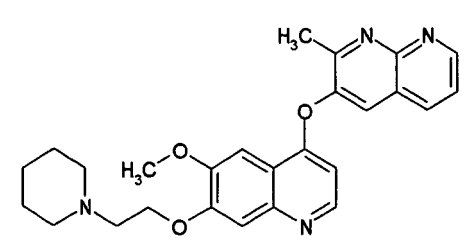
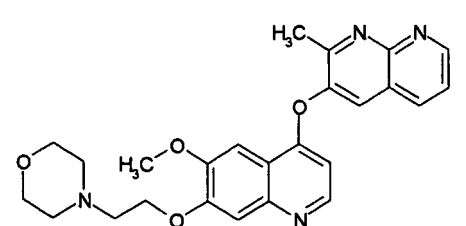
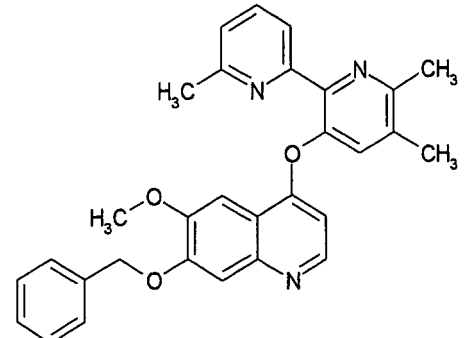
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 435		79	29	
r 436		100	99	
r 437		100	95	
r 438		100	99	

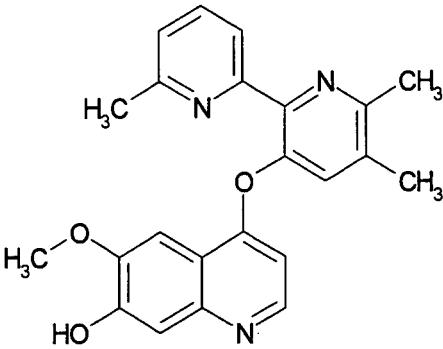
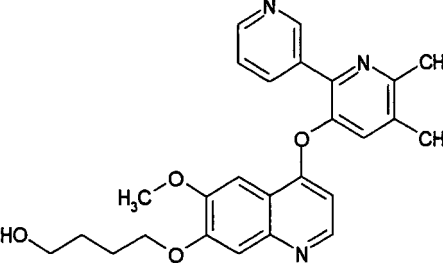
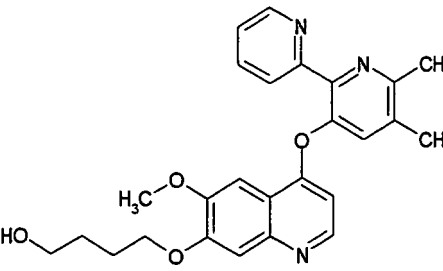
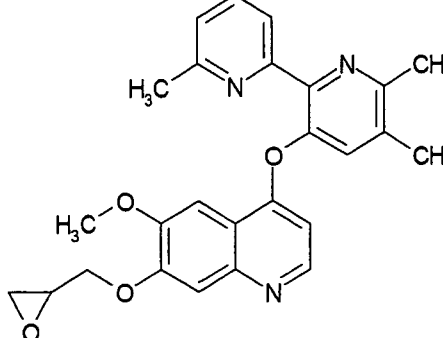
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 439		95	43	
r 440		100	100	
r 441		100	97	
r 442		100	70	

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(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 443		97	60	
r 444			100	
r 445			99	
r 446		89	35	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 447		100	94	
r 448		97	70	
r 449		98	74	
r 450		100	94	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 451		100	99	
r 452		99	67	
r 453		98	72	
r 454		75	41	

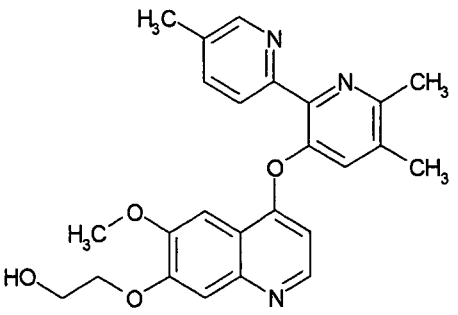
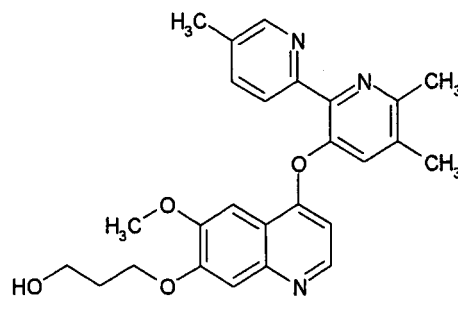
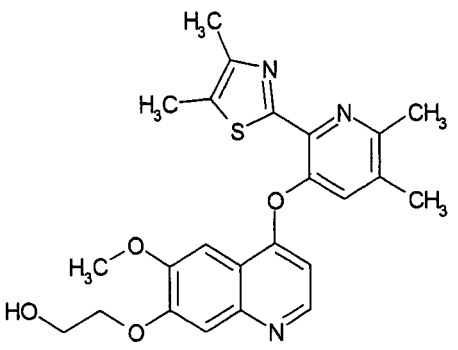
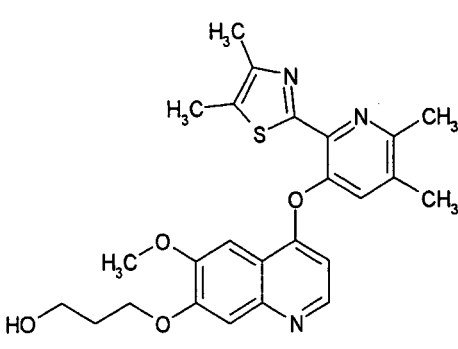
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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 455		99	76	
r 456		100	99	
r 457		100	97	
r 458		100	94	

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(continued)

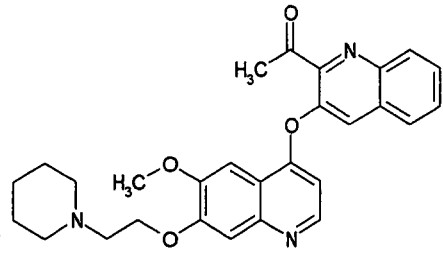
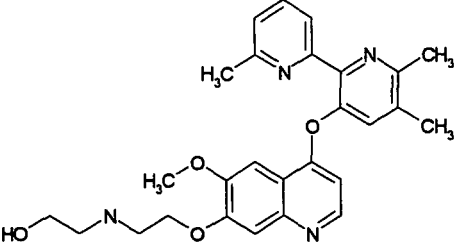
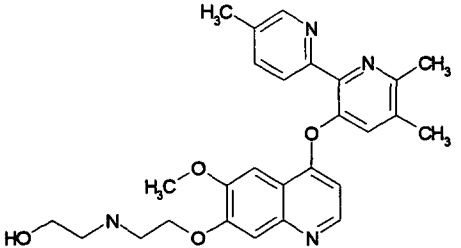
Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 459			98	
r 460			97	
r 461			82	
r 462			99	

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(continued)

Compound	Molecular structure	TGFβ inhibition rate, %		
		10 μM	3 μM	1 μM
r 463		99	77	
r 464		100	97	
r 465		100	98	
r 466		100	99	

(continued)

Compound	Molecular structure	TGF β inhibition rate, %		
		10 μ M	3 μ M	1 μ M
r 467			100	
r 468			99	
r 469			100	

Test Example 2: Measurement of anti-fibrotic activity using mouse unilateral ureteral obstruction (UUO) model

[0544] The anti-fibrotic activity of the compounds related to the present invention was evaluated using a mouse unilateral ureteral obstruction (UUO) model which is a renal fibrosis model. Compound r384 produced in the working example was used as the test compound.

Seven week-old male BALB/c mice (available from Charles River Japan, Inc.) were purchased and were pre-raised before use in experiments. Regarding diets and drinking water, pellets CE-2 (available from CLEA JAPAN INC.) and sterile tap water were freely fed.

The mice underwent laparotomy under pentobarbital anesthesia, and the left renal urinary duct was ligated. Thereafter, the mice underwent suturing operation and were divided into a vehicle administration group (n = 7) and a test compound administration group (n = 7) using the weight as an index.

The test compound was weighed, and then one drop of 1 N HCl was added to the test compound to prepare a solution. The solution was then suspended in 0.5% carboxymethylcellulose (solvent). The suspension was forcibly orally administered twice a day with an oral sonde from the day of urinary duct ligation (5, 15, or 50 mg/kg). The solvent was administered to the vehicle administration group in the same manner as described just above.

[0545] After administration for 4 days, the mouse left kidney was removed, and the hydroxyproline content as an index of organ fibrosis was measured by the following method.

Renal pieces were first placed in 6 N HCl, were homogenized, and were then heated on a heat block at 130°C for 3 hr to hydrolyze protein. Thereafter, the suspension of renal pieces was neutralized by the addition of an appropriate amount of 4 N NaOH. The neutralized suspension was centrifuged (1000 rpm, 5 min, room temperature) to obtain the supernatant as a kidney extract. A chloramine T liquid, a perchloric acid solution (a solution prepared by adding distilled water to

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31.5 ml of 60% perchloric acid to adjust the total volume to 100 ml), and a p-dimethylaminobenzaldehyde solution (a solution prepared by adding methylcellulose to 20 g of p-dimethylaminobenzaldehyde to adjust the total volume to 100 ml) were added to the kidney extract, and the reaction was allowed to proceed at 60°C for 20 min. The absorbance at 557 nM was then measured. The content of hydroxyproline was determined from the measured data based on a calibration curve for hydroxyproline prepared using control. Further, the content of hydroxyproline thus determined was corrected according to the weight of the homogenized kidney.

[0546] The results were as shown in Table 2. The values in the table are average of data on 7 mice for each group \pm standard deviation.

The result showed that the content of hydroxyproline in the UO treatment mouse kidney was increased as compared with the kidney of normal mice, suggesting that extracellular matrix proteins were accumulated within the kidney. In contrast, the content of hydroxyproline in the mouse to which the test compound had been administered was lowered, as compared with that of the solvent administration group, indicating that the compound could suppress the accumulation of extracellular matrix proteins in the kidney.

[0547]

Table 2:

Administration group	Hydroxyproline content (mg/g)
Normal mice	392.9 \pm 10.8
UO treatment + solvent	549.4 \pm 15.2 ###
UO treatment + compound r384 (5 mg/kg)	514.4 \pm 20.8
UO treatment + compound r384 (15 mg/kg)	487.7 \pm 10.9 **
UO treatment + compound r384 (50 mg/kg)	425.7 \pm 14.2 ***

In the table, ### indicates that $p < 0.001$ in Student's t-test against the normal mouse group, and ** and *** respectively indicate that $p < 0.01$ and $p < 0.001$ in Student's t-test against UO treatment + solvent group.

Test Example 3: Measurement of anti-fibrotic activity using mouse unilateral ureteral obstruction (UO) model

[0548] The anti-fibrotic activity of a compound related to the present invention was evaluated using the same model as used in Test Example 2.

Compound r320 prepared in the working example was used as the test compound.

The experiment method and evaluation method were the same as those in Test Example 2, except that the compound administration was carried out by feeding a diet mixed with the compound for 10 days and the correction of hydroxyproline content was changed to the content of protein in the kidney extract.

The results were as shown in Table 3. The values in the table are average of data on five mice for each group \pm standard deviation.

The result showed that the content of hydroxyproline in the UO treatment mouse kidney was increased as compared with the kidney of normal mice, suggesting that extracellular matrix was accumulated within the kidney. In contrast, the content of hydroxyproline in the mouse to which the test compound had been administered was lowered, as compared with that of the solvent administration group, indicating that the compound could suppress the accumulation of extracellular substrate in the kidney.

[0549]

Table 3:

Administration group	Hydroxyproline content (mg/g protein)
Normal mice	6.7 \pm 1.26
UO treatment + solvent	12.7 \pm 1.14 #
UO treatment + compound r320 (0.1% mixed feed)	9.44 \pm 0.53 *
UO treatment + compound r320 (0.3% mixed feed)	9.19 \pm 0.38 *

In the table, # indicates that $p < 0.05$ in Student's t-test against the normal mouse group, and ** indicates that $p < 0.05$ in Student's t-test against UO treatment + solvent group.

Test Example 4: Measurement of anti-fibrotic activity using mouse DMN hepatic fibrosis model

[0550] The anti-fibrotic activity of a compound related to the present invention was evaluated using a mouse DMN

hepatic fibrosis model as a liver fibrosis model. Compound r384 prepared in the working example was used as the test compound.

Six-week-old male BALB/c mice (available from Charles River Japan, Inc.) were purchased and were pre-raised before use in experiments.

The mice were divided into a vehicle administration group (n = 6) and a test compound administration group (n = 7) using the weight as an index. Thereafter, dimethylnitrosoamine (DMN) diluted with physiological saline was intraperitoneally administered at 15 mg/kg three times per week for 3 weeks to induce hepatic fibrosis.

The administration of the test compound was carried out from the first day of the DMN administration. The test compound was mixed at the dosage of 0.015, 0.03, and 0.06% in powder diet CE-2 (available from CLEA JAPAN INC.), and the mixtures were fed as a diet to each mouse group.

After 21 days, the mice underwent laparotomy under ether anesthesia, and blood was collected from the heart, followed by measurement of the level of hyaluronic acid in blood as an index of hepatic fibrosis using a hyaluronic acid plate (Chugai Pharmaceutical Co., Ltd.).

[0551] The results were as shown in Table 4. The values in the table are average of data on 6 mice for each group \pm standard deviation.

The result showed that the blood hyaluronic acid level in the mouse liver to which DMN had been administered was increased as compared with the liver of normal mice, suggesting that extracellular matrix proteins were accumulated within the liver. In contrast, the blood hyaluronic acid level in the mouse to which the test compound had been administered was lowered as compared with that of the solvent administration group, indicating that the compound could suppress the accumulation of extracellular matrix proteins in the liver.

[0552]

Table 4:

Administration group	Blood hyaluronic acid content (ng/ml)
Normal mice	113.8 \pm 14.9
DMN administration + solvent	326.4 \pm 47.1 ## 326.4 \pm 47.1 ##
DMN administration + compound r384 (0.015% mixed feed)	167.8 \pm 25.0 *
DMN administration + compound r384 (0.03% mixed feed)	108.5 \pm 9.0 **
DMN administration + compound r384(0.06% mixed feed)	97.2 + 11.0**

In the table, ## indicates that $p < 0.01$ in Student's t-test against the normal mouse group, and * and ** respectively indicate that $p < 0.05$ and $p < 0.01$ in Student's t-test against UJO treatment + solvent group.

Test Example 5: Measurement of anti-fibrotic activity using rat unilateral ureteral obstruction (UJO) model

[0553] The anti-fibrotic activity of the compounds described in the present specification was evaluated using a rat unilateral ureteral obstruction (UJO) model which is a renal fibrosis model. Compound 50 and compound 159 were used as the test compound.

Six week-old male SD rats (available from Charles River Japan, Inc.) were purchased and were pre-raised before use in experiments. Regarding diets and drinking water, pellets CE-2 (available from CLEA JAPAN INC.) and sterile tap water were freely fed.

The rats underwent laparotomy under pentobarbital anesthesia, and the left renal urinary duct was ligated. Thereafter, the mice underwent suturing operation and were divided into a vehicle administration group (n = 6) and a test compound administration group (n = 6) using the weight as an index.

The test compound was mixed in amounts of 0.03% and 0.1% in powder diet CE-2 (available from CLEA JAPAN INC.), and the mixtures were fed as a diet to each rat group from the first day of the ureteral obstruction.

[0554] After administration of the mixed feed for 7 days, the left kidney was removed, and the hydroxyproline content as an index of organ fibrosis was measured by the following method. Specifically, renal pieces were first placed in 6 N HCl, were homogenized, and were then heated on a heat block at 130°C for 3 hr to hydrolyze protein. Thereafter, the suspension of renal pieces was neutralized by the addition of an appropriate amount of 4 N NaOH. The neutralized suspension was centrifuged (1000 rpm, 5 min, room temperature) to obtain the supernatant as a kidney extract. A chloramine T liquid, a perchloric acid solution (a solution prepared by adding distilled water to 31.5 ml of 60% perchloric acid to adjust the total volume to 100 ml), and a p-dimethylaminobenzaldehyde solution (a solution prepared by adding methylcellulose to 20 g of p-dimethylaminobenzaldehyde to adjust the total volume to 100 ml) were added to the kidney extract, and a reaction was allowed to proceed at 60°C for 20 min. The absorbance at 557 nm was then measured. The

content of hydroxyproline was determined from the measured data based on a calibration curve for hydroxyproline prepared using control. Further, the content of hydroxyproline thus determined was corrected according to the total protein content of the kidney extract.

[0555] The results were as shown in Tables 5a and 5b.

The values in the tables are average of data on 6 rats for each group \pm standard deviation. The result showed that the content of hydroxyproline in the UUO treatment rat kidney was increased, as compared with the kidney of normal rats, suggesting that extracellular matrix proteins were accumulated within the kidney. In contrast, the content of hydroxyproline in the rat administrated the test compounds was lowered as compared with the solvent administration group, for the group to which had been administered, , indicating that the compounds could suppress the accumulation of extracellular matrix proteins in the kidney.

[0556]

Table 5a:

Administration group	Hydroxyproline content (mg/g)
Normal rats	4.47 \pm 0.17
UUO treatment + solvent	8.24 \pm 0.31 ###
UUO treatment + compound 50 (0.03% mixed feed)	7.33 \pm 0.67
UUO treatment + compound 50 (0.1% mixed feed)	4.67 \pm 0.22 ***

[0557]

Table 5b:

Administration group	Hydroxyproline content (mg/g)
Normal rats	18.84 \pm 1.05
UUO treatment + solvent	27.16 \pm 2.65 ###
UUO treatment + compound 159 (0.03% mixed feed)	22.47 \pm 0.82
UUO treatment + compound 159 (0.1% mixed feed)	17.28 \pm 0.87 ***

In the tables, ### indicates that $p < 0.001$ in Student's t-test against the normal rat group, and *** indicates that $p < 0.001$ in Student's t-test against UUO treatment + solvent group.

Test Example 6: Measurement of cell growth inhibitory activity using A549 cells

[0558] Human lung cancer epithelial cells (A549) (available from ATCC) were suspended to a concentration of 3×10^4 /ml in a DMEM/F12 medium containing 10%FCS, and the suspension was inoculated in 100 μ l portions in wells of a 96-well plate.

On the following day, a stock solution of the test compound which had been adjusted to 10 mM with DMSO was adjusted with a serum-free DMEM/F12 medium to a dose (60 μ M) which was twice the evaluation concentration. After removing the medium inoculated in the 96 wells on the previous day, the solution was added in 50 μ l portions to the plate. Next, a DMEM/F12 medium containing 10% serum was added in 50 μ l portions to the wells, followed by culturing at 37°C for 40 hr.

The final concentration of the serum and the concentration of the evaluation compound were 5% and 30 μ M, respectively. The compounds according to the present invention synthesized in the working example were used as the test compound. Compounds 261, 269 and 274 described in WO 2004/018430 were used as the comparative compound.

[0559] After 40 hr, the culture was removed, and 100 μ l of a solution prepared by diluting counting kit-8 (purchased from Dojindo) with a serum-free F12 medium by 10 times was added, followed by culturing at 37°C for 20 to 30 min. After the confirmation of suitable color development, the absorbance at 450 nm was measured with ARVO (purchased from Wallach Bethold Japan). The cell growth inhibition in the test compound added wells were determined by presuming the absorbance value in the test compound-free wells to be 0% and the absorbance value in the cell-free wells to be 100%.

[0560] The results were as shown in Table 6. As is apparent from Table 6, the conventional compounds had a cell growth inhibition of about 30% to 45%, whereas the test compounds had substantially no cell growth inhibitory activity, indicating that the test compounds had a significantly improved potential as a medicament.

[0561]

Table 6:

Test compound	Cell growth inhibition rate (%)
Compound 261 of WO 2004/018430	44
Compound 269 of WO 2004/018430	45
Compound 205	9
Compound 179	-3
Compound 181	-7
Compound 182	-8
Compound 184	8
Compound 186	-2
Compound 187	0
Compound 274 of WO 2004/018430	25
Compound 192	3
Compound 194	-15
Compound 200	0
Compound 201	2
Compound 202	8
Compound 204	-9
Compound 206	-1
Compound 217	4
Compound 222	6
Compound 225	8

Test Example 7: Measurement of BMP signal inhibitory activity (in-vitro test)

[0562] The inhibitory activity of the compounds according to the present invention against BMP signals was studied using a cell line through which TGF β and BMP signals can be simultaneously observed.

Specifically, the cell lines capable of detecting the two signal was generated by transfecting reporter plasmids for detection of TGF β and BMP signals into a human hepatocarcinoma cell line HepG2(available from ATCC) and was used as evaluation cells. For detection of TGF-beta signal, the plasmid having four tandem binding sequences of Smad2/3, TGF-beta signal transducers, to the upstream of a luciferases gene were used as a reporter plasmid (p(SBE)4-Luc/hygro).

For detection of BMP signal, the plasmid having twelve tandem binding sequences of Smad1/5/8, BMP signal transducers, to the upstream of a luciferases gene were used as a reporter plasmid (p(GCCG)12-Luc/neo), according to the method described in Mol Biol Cell. 2000 11(2): 555-65.

The test compound and TGF β -1 (2 ng/ml) or BMP4 (20 ng/ml) were added to the cells, and the mixture was cultured for 4 hr. The compounds according to the present invention synthesized in the working example were used as the test compound. Compounds 261, 269 and 274 described in WO 2004/018430 were used as the comparative compound. After the culture, the luciferase activity of the cells was measured by chemiluminescence (Steady Glo (trademark) luciferase assay system, available from Promega).

Likewise, the luciferase activity was measured as control for the culture of cells with only TGF β or BMP4 added thereto and the culture of cells with the addition of none of TGF β , BMP4 and the test compound.

The inhibitory activity IC₅₀ of the compounds against TGF β and BMP4 was calculated based on the results of measurement, and the kinase selectivity for BMP4 was determined by the following method.

Kinase selectivity for BMP4 (times) = Inhibitory activity against BMP4 signal (IC₅₀)/Inhibitory activity against TGF β signal (IC₅₀)

[0563] The results were as shown in Table 7.

As is apparent from the table, the selectivity of the conventional compounds was as low as about four times to ten times, whereas, for all the test compounds, the selectivity for BMP signal was 20 times or higher, indicating that the test compounds had a significantly improved potential as a medicament.

[0564]

Table 7:

Test compound	Selectivity for BMP (times)
Compound 261 of WO 2004/018430	4.1

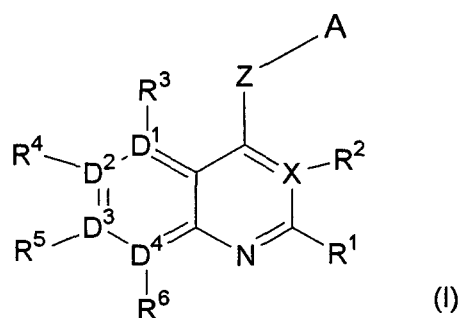
(continued)

Test compound	Selectivity for BMP (times)
Compound 269 of WO 2004/018430	11.9
Compound 181	308
Compound 182	195
Compound 184	> 428
Compound 187	72
Compound 274 of WO 2004/018430	6.7
Compound 192	> 176
Compound 194	51
Compound 200	75
Compound 202	21.4

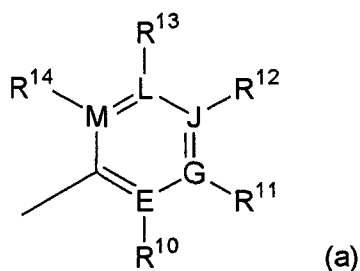
[0565] This application is based upon and claims the benefit of priority from the prior Japanese Patent Applications No. 45383/2004, filed on February 20, 2004, the entire contents of which are incorporated herein by reference.

Claims

1. A compound of formula (I) or a pharmaceutically acceptable salt or solvate thereof:



wherein
A represents a group of formula (a):



Z represents -O-, -N(-R^Z)-, -S-, or -C(=O)- wherein R^Z represents a hydrogen atom or unsubstituted C1-4 alkyl, D¹, D², D³, D⁴, X, E, G, J, L, and M, which may be the same or different, represent C or N, R¹ to R⁶ and R¹⁰ to R¹⁴, which may be the same or different, represent

- (1) a hydrogen atom;
- (2) a halogen atom;
- (3) hydroxyl;
- (4) cyano group;

- (5) nitro group;
 (6) C1-6 alkyl;
 (7) C2-6 alkenyl;
 (8) C2-6 alkynyl;
 (9) C1-6 alkoxy;
 (10) C1-6 alkylthio;

wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

- (I) hydroxyl,
 (II) a halogen atom,
 (III) C1-4 alkoxy,
 (IV) an oxygen atom,
 (V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, or a five- or six-membered carbocyclic or heterocyclic group, and the C1-4 alkyl group is optionally substituted by hydroxyl or phenyl,
 (VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl or a five- or six-membered carbocyclic or heterocyclic group, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy,
 (VII) -NHCONHR^{VII} wherein R^{VII} represents C1-4 alkyl,
 (VIII) -OCOR^{VIII} wherein R^{VIII} represents C1-6 alkyl optionally substituted by amino, or
 (IX) -NSO₂R^{IX} wherein R^{IX} represents C1-4 alkyl;

- (11) -NR^aR^b;
 (12) -CO-OR^c;
 (13) -CO-NR^dR^e;

wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

- (a) hydroxyl,
 (b) a halogen atom,
 (c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and

R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom or may contain one or more additional heteroatoms;

- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group;
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;
 (17) -OCOR^k wherein R^k represents C1-4 alkyl; or
 (18) -OSO₂R^L wherein R^L represents C1-4 alkyl,

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and R¹⁰ and R¹¹, R¹¹ and R¹², R¹² and R¹³, and R¹³ and R¹⁴ together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, and the carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen

atom or C1-4 alkyl,

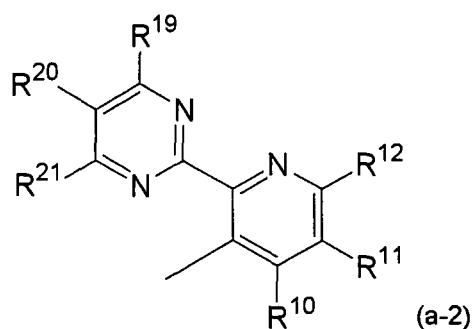
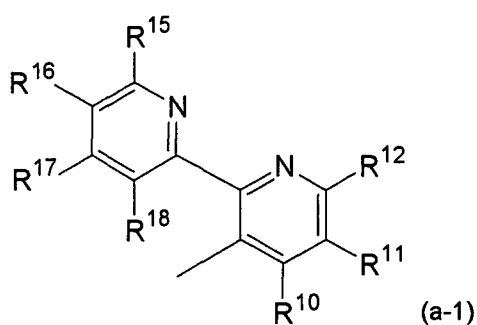
provided that, when D¹, D², D³, D⁴, X, E, G, J, L, and M represent a nitrogen atom, groups R² to R⁶ and R¹⁰ to R¹⁴ which attach to the nitrogen atom are absent, and

provided that, when all of D¹, D², D³, and D⁴ represent a carbon atom,

I) at least one of R⁴ and R⁵ represents (4) cyano group, (5) nitro group, (12) -CO-OR^c, (13) -CO-NR^dR^e wherein any one of R^d and R^e represents optionally substituted C1-4 alkyl, (14) carbocyclic group, (15) heterocyclic group wherein the heterocyclic group contains at least one substituent, or (16) bicyclic carbocyclic group or heterocyclic group, or

II) L represents a nitrogen atom, E, G, J, and M represent a carbon atom, R¹⁰ represents a hydrogen atom, and R¹⁴ represents (6) C1-6 alkyl group, (14) carbocyclic group, (15) heterocyclic group, or (16) bicyclic carbocyclic group or heterocyclic group.

2. The compound according to claim 1, wherein at least one of D¹ to D⁴ represents a nitrogen atom.
3. The compound according to claim 1, wherein D¹ represents a nitrogen atom and, at the same time, all of D² to D⁴ represent a carbon atom.
4. The compound according to claim 1, wherein D² represents a nitrogen atom and, at the same time, all of D¹, D³, and D⁴ represent a carbon atom.
5. The compound according to any one of claims 2 to 4, wherein, in the group of formula (a), any one of E, G, J, L, and M represents a nitrogen atom and all the others represent a carbon atom.
6. The compound according to any one of claims 2 to 4, wherein L represents a nitrogen atom and E, G, J, and M represent a carbon atom.
7. The compound according to any one of claims 2 to 6, wherein R¹⁰ represents a hydrogen atom, and R¹¹ and R¹² are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.
8. The compound according to any one of claims 2 to 7, wherein R¹⁴ represents an optionally substituted saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group.
9. The compound according to claim 8, wherein R¹⁴ represents an optionally substituted unsaturated six-membered heterocyclic group.
10. The compound according to any one of claims 2 to 9, wherein A represents a group of formula (a-1) or (a-2):



wherein

R¹⁰ to R¹² are as defined in claim 1, and

R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, represent (0) a hydrogen atom, (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h

wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

11. The compound according to claim 10, wherein, in the group of formula (a-1) or (a-2), R¹⁵ to R¹⁸ and R¹⁹ to R²¹ are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

12. The compound according to claim 10 or 11, wherein

R¹⁰ represents a hydrogen atom,

R¹¹ and R¹² are selected from the group consisting of a hydrogen atom and C1-4 alkyl, and

R¹⁵ to R¹⁸ and R¹⁹ to R²¹ in the group of formula (a-1) or (a-2) are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

13. The compound according to claim 10 or 11, wherein

R¹⁰ represents a hydrogen atom,

R¹¹ and R¹² are selected from the group consisting of a hydrogen atom and C1-4 alkyl, and

all of R¹⁵ to R¹⁸ and R¹⁹ to R²¹ in the group of formula (a-1) or (a-2) represent a hydrogen atom.

14. The compound according to claim 12 or 13, wherein Z represents -O-, X represents a carbon atom, and R¹ to R³ and R⁶ represent a hydrogen atom.

15. The compound according to any one of claims 2 to 6, wherein

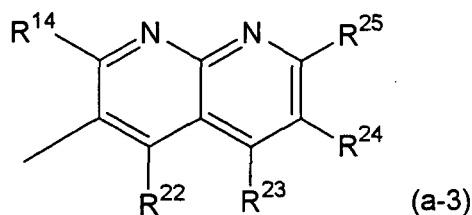
R¹⁰ represents a hydrogen atom, and

R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group.

16. The compound according to claim 15, wherein R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent a unsaturated six-membered carbocyclic or heterocyclic group.

17. The compound according to any one of claims 2 to 4,

wherein A represents a group of formula (a-3):



wherein

R¹⁴ is as defined in claim 1, and

R²² to R²⁵, which may be the same or different, represent (0) a hydrogen atom, (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl).

18. The compound according to claim 17, wherein R²² to R²⁵ in the group of formula (a-3) are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

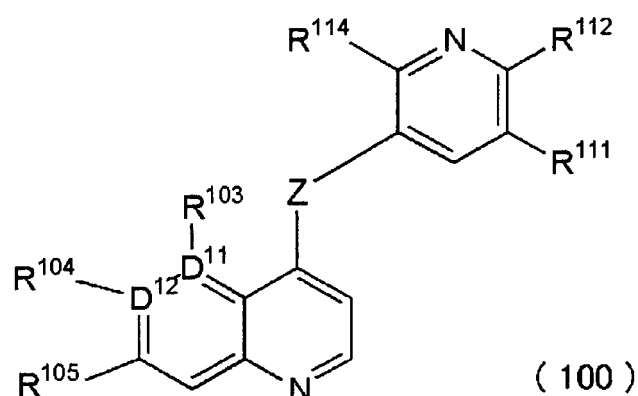
19. The compound according to claim 17, wherein all of R²² to R²⁵ in the group of formula (a-3) represent a hydrogen atom.

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20. The compound according to any one of claims 17 to 19, wherein R¹⁴ represents optionally substituted C1-4 alkyl, an optionally substituted saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, or an optionally substituted bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group.
21. The compound according to claim 20, wherein R¹⁴ represents unsubstituted C1-4 alkyl.
22. The compound according to claim 20, wherein R¹⁴ represents an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group.
23. The compound according to any one of claims 2 to 22, wherein X represents a carbon atom and both R¹ and R² represent a hydrogen atom.
24. The compound according to claim 23, wherein D¹ represents a nitrogen atom and all of D² to D⁴ represent a carbon atom, and R⁶ represents a hydrogen atom.
25. The compound according to claim 23, wherein D² represents a nitrogen atom and all of D¹, D³, and D⁴ represent a carbon atom, and R³ represents a hydrogen atom or a halogen atom, and R⁶ represents a hydrogen atom.
26. The compound according to claim 23, wherein all of R¹, R², R³ and R⁶ represent a hydrogen atom.
27. The compound according to any one of claims 2 to 26, wherein R⁴ and R⁵, which may be the same or different, represent
- (1) a hydrogen atom;
 - (2) a halogen atom;
 - (3) hydroxyl;
 - (6) C1-6 alkyl;
 - (9) C1-6 alkoxy;
 - (12) -CO-OR^c;
 - (13) -CO-NR^dRe;
 - (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 - (15) a saturated or unsaturated three- to nine-membered heterocyclic group;
 - (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;
 - (17) -OCOR^k wherein R^k represents C1-4 alkyl; or
 - (18) -OSO₂R^L wherein R^L represents C1-4 alkyl,
- wherein these groups are optionally substituted as defined in claim 1.
28. The compound according to any one of claims 1 to 27, wherein Z represents -O-.
29. The compound according to any one of claims 1 to 28, wherein X represents a carbon atom.
30. The compound according to claim 1 or a pharmaceutically acceptable salt or solvate thereof, wherein formula (I) is represented by formula (100):

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wherein

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Z represents -O-, -NH-, -S-, or -C(=O)-,
 any one of D¹¹ and D¹² represents a nitrogen atom, and the other represents a carbon atom,
 R¹⁰³ represents a hydrogen atom or a halogen atom,
 R¹⁰⁴ and R¹⁰⁵, which may be the same or different, represent

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(1) a hydrogen atom ;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

(9) C1-6 alkoxy;

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(12) -CO-OR^c;

(13) -CO-NR^dRE;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,

wherein these groups are optionally substituted as defined in claim 1,

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R¹¹¹ and R¹¹², which may be the same or different, are selected from the group consisting of a hydrogen atom, C1-4 alkyl, and C1-4 alkoxy, and

R¹¹⁴ represents

(14^{''}) a saturated or unsaturated five- or six-membered carbocyclic group;

(15^{''}) a saturated or unsaturated five- or six-membered heterocyclic group; or

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(16^{''}) a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;

wherein (14^{''}) carbocyclic group, (15^{''}) heterocyclic group, and (16^{''}) bicyclic carbocyclic group or heterocyclic

group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino

group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi)

C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-

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NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

31. The compound according to claim 30, wherein Z represents -O-.

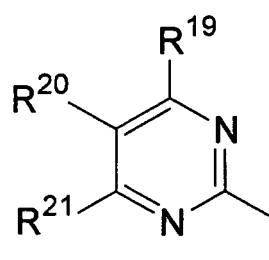
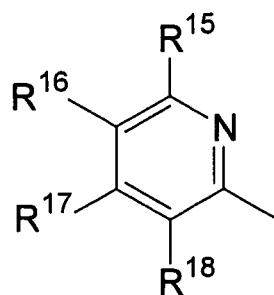
32. The compound according to claim 30 or 31, wherein R¹⁰³ represents a hydrogen atom.

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33. The compound according to any one of claims 30 to 32, wherein both R¹¹¹ and R¹¹² represent methyl, or R¹¹¹ represents a hydrogen atom, and R¹¹² represents ethyl.

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34. The compound according to any one of claims 30 to 33, wherein R¹¹⁴ represents a group of formula (a-4) or (a-5):



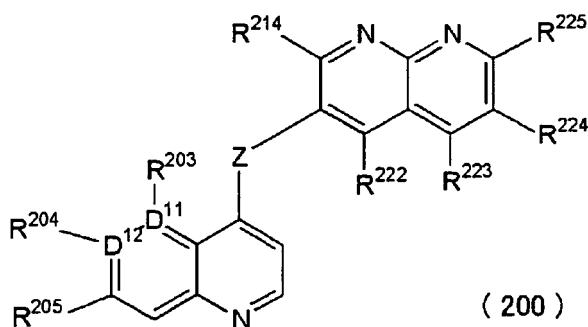
wherein

15 R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

35. The compound according to claim 34, wherein all of R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.

36. The compound according to any one of claims 30 to 35, wherein both R¹⁰⁴ and R¹⁰⁵ represent a hydrogen atom.

37. The compound according to claim 1 or a pharmaceutically acceptable salt or solvate thereof, wherein formula (I) is represented by formula (200):



wherein

Z represents -O-, -NH-, -S-, or -C(=O)-,

any one of D¹¹ and D¹² represents a nitrogen atom, and the other represents a carbon atom,

R²⁰³ represents a hydrogen atom or a halogen atom,

R²⁰⁴ and R²⁰⁵, which may be the same or different, represent

(1) a hydrogen atom ;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

(9) C1-6 alkoxy;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group, wherein these groups are optionally substituted as defined in claim 1),

R²²² to R²²⁵, which may be the same or different, are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, and

R²¹⁴ represents

unsubstituted C1-4 alkyl,

an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group, or

an optionally substituted, bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group.

38. The compound according to claim 37, wherein Z represents -O-.

39. The compound according to claim 37 or 38, wherein R²⁰³ represents a hydrogen atom.

40. The compound according to any one of claims 37 to 39, wherein all of R²²² to R²²⁵ represent a hydrogen atom.

41. The compound according to any one of claims 37 to 40, wherein R²¹⁴ represents phenyl.

42. The compound according to any one of claims 37 to 40, wherein R²¹⁴ represents methyl or ethyl.

43. The compound according to any one of claims 37 to 42, wherein both R²⁰⁴ and R²⁰⁵ represent a hydrogen atom.

44. The compound according to claim 1, wherein all of D¹ to D⁴ represent a carbon atom, R¹ and R² represent a hydrogen atom, and R³ and R⁶, which may be the same or different, represent a hydrogen atom, a halogen atom, or C1-4 alkyl, and R⁴ and R⁵, which may be the same or different, represent

(4) cyano group;

(5) nitro group;

(12) -CO-OR^c;

(13) -CO-NR^dR^e;

wherein, in groups (12) and (13), R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, provided that at least one of R^d and R^e represents C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

(a) hydroxyl,

(b) a halogen atom,

(c) C1-4 alkoxy,

(d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or

(e) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl,

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic group or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and (15) heterocyclic group contain at least one substituent.

45. The compound according to claim 44, wherein

R⁴ and R⁵ represent

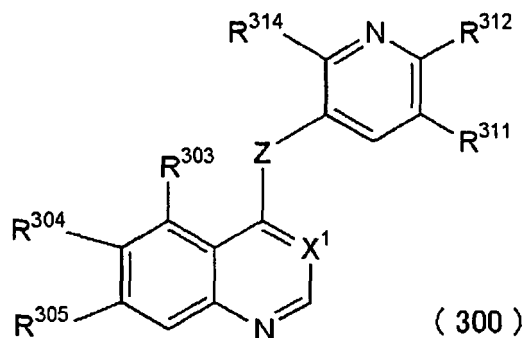
an unsaturated five- or six-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl, or a bicyclic unsaturated nine- or ten-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl.

46. The compound according to claim 44 or 45, wherein L represents a nitrogen atom, and E, G, J, and M represent a carbon atom.

47. The compound according to any one of claims 44 to 46, wherein R¹⁴ represents

(6) C1-6 alkyl; wherein the alkyl group is optionally substituted as defined in claim 1,
 (14ⁿ) a saturated or unsaturated five- or six-membered carbocyclic group;
 (15ⁿ) a saturated or unsaturated five- or six-membered heterocyclic group; or
 (16ⁿ) a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;
 wherein (14ⁿ) carbocyclic group, (15ⁿ) heterocyclic group, and (16ⁿ) bicyclic carbocyclic group or heterocyclic
 group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino
 group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi)
 C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-
 NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

48. The compound according to claim 1 or a pharmaceutically acceptable salt or solvate thereof, wherein formula (I) is
 represented by formula (300):



wherein

X¹ represents CH or N,

Z represents -O-, -NH-, -S-, or -C(=O)-,

R³⁰³ represents a hydrogen atom, a halogen atom, or C1-4 alkyl,

R³⁰⁴ and R³⁰⁵, which may be the same or different, represent

- (1) a hydrogen atom;
- (2) a halogen atom;
- (3) hydroxyl;
- (6) C1-6 alkyl;
- (9) C1-6 alkoxy;
- (12) -CO-OR^c;
- (13) -CO-NR^dR^e;
- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
- (15) a saturated or unsaturated three- to nine-membered heterocyclic group;
- (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;
- (17) -OCOR^k wherein R^k represents C1-4 alkyl; or
- (18) -OSO₂R^l wherein R^l represents C1-4 alkyl,

wherein these groups are optionally substituted as defined in claim 1,

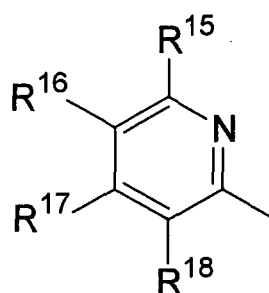
at least one of R³¹¹ and R³¹² represents C1-4 alkyl and the other represents a hydrogen atom or C1-4 alkyl, and
 R³¹⁴ represents an unsaturated six-membered heterocyclic group wherein the heterocyclic group is optionally sub-
 stituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two
 hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii)
 C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which
 may be the same or different, represent a hydrogen atom or C1-4 alkyl.

49. The compound according to claim 48, wherein
 Z represents -O-,

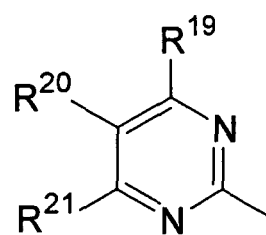
R³⁰³ represents a hydrogen atom, and
R³⁰⁴ represents

- (1) a hydrogen atom ;
(2) a halogen atom;
(3) hydroxyl;
(9) C1-6 alkoxy;
(17) -OCOR^k wherein R^k represents C1-4 alkyl; or
(18) -OSO₂R^L wherein R^L represents C1-4 alkyl,

wherein these groups are optionally substituted as defined in claim 1,
R³⁰⁵ represents a hydrogen atom, a halogen atom, or -CO-NH₂, and
R³¹⁴ represents a group of formula (a-4) or (a-5):



(a-4)



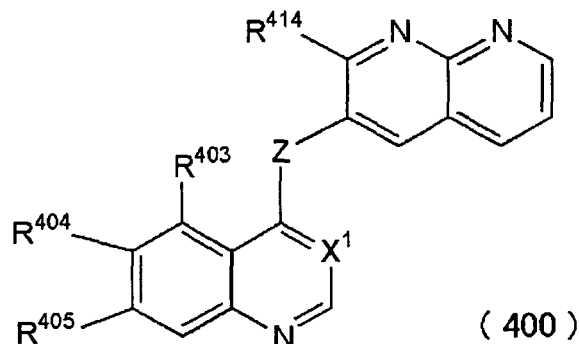
(a-5)

wherein

R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

50. The compound according to claim 49, wherein R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.
51. The compound according to any one of claims 48 to 50, wherein X¹ represents CH.
52. The compound according to any one of claims 48 to 51, wherein R³⁰⁵ represents a hydrogen atom, a fluorine atom, or -CO-NH₂.
53. The compound according to any one of claims 48 to 52, wherein R³¹¹ and R³¹², which may be the same or different, represent C1-4 alkyl.
54. The compound according to claim 53, wherein both R³¹¹ and R³¹² represent methyl.
55. The compound according to any one of claims 48 to 52, wherein R³¹¹ represents a hydrogen atom, and R³¹² represents C1-4 alkyl.
56. The compound according to claim 55, wherein R³¹¹ represents a hydrogen atom, and R³¹² represents methyl.
57. The compound according to claim 55, wherein R³¹¹ represents a hydrogen atom, and R³¹² represents ethyl.
58. The compound according to any one of claims 48 to 57, wherein R³⁰⁴ represents C1-6 alkoxy optionally substituted as defined in claim 1.

59. The compound according to claim 58, wherein R^{304} represents C1-6 alkoxy substituted by hydroxyl.
60. The compound according to claim 58, wherein R^{304} represents $-O(CH_2)_{m1}-OH$ wherein $m1$ is an integer of 2 to 4.
- 5 61. The compound according to claim 58, wherein R^{304} represents $-OC_2H_5-OH$.
62. The compound according to claim 48, which is selected from the group consisting of compounds 181, 188, 192, 200, 202, and 205.
- 10 63. The compound according to claim 1 or a pharmaceutically acceptable salt or solvate thereof, wherein formula (I) is represented by formula (400):



wherein

X^1 represents CH or N,

Z represents $-O-$, $-NH-$, $-S-$, or $-C(=O)-$,

30 R^{403} represents a hydrogen atom, a halogen atom, or C1-4 alkyl,

R^{404} and R^{405} , which may be the same or different, represent

- 35 (1) a hydrogen atom ;
 (2) a halogen atom;
 (3) hydroxyl;
 (6) C1-6 alkyl;
 (9) C1-6 alkoxy;
 (12) $-CO-OR^c$;
 (13) $-CO-NR^dR^e$;
 40 (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group;
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;
 (17) $-OCOR^k$ wherein R^k represents C1-4 alkyl; or
 (18) $-OSO_2R^l$ wherein R^l represents C1-4 alkyl,

45 wherein these groups are optionally substituted as defined in claim 1, and

R^{414} represents

(6) C1-6 alkyl;

wherein the alkyl group is optionally substituted as defined in claim 1,

(14") a saturated or unsaturated five- or six-membered carbocyclic group;

50 (15") a saturated or unsaturated five- or six-membered heterocyclic group; or

(16") a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;

wherein (14") carbocyclic group, (15") heterocyclic group, and (16") bicyclic carbocyclic group or heterocyclic

group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino

group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi)

55 C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) $-CO-OR^f$, or (xii) $-CO-$

NR^gR^h wherein R^f , R^g , and R^h , which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

64. The compound according to claim 63, wherein

Z represents -O-,

R⁴⁰³ represents a hydrogen atom, and

R⁴¹⁴ represents

an unsaturated five- or six-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl, or a bicyclic unsaturated nine- or ten-membered carbocyclic or heterocyclic group wherein the carbocyclic or heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, a halogen atom, amino group, or hydroxyl.

65. The compound according to claim 63, wherein

X¹ represents CH,

Z represents -O-,

R⁴⁰³ represents a hydrogen atom,

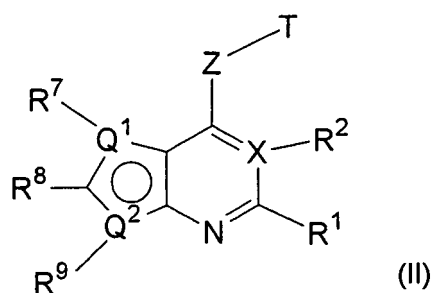
any one of R⁴⁰⁴ and R⁴⁰⁵ represents C1-4 alkoxy substituted by hydroxyl, and the other represents unsubstituted C1-4 alkoxy, and

R⁴¹⁴ represents phenyl.

66. The compound according to claim 63, which is compound 178.

67. The compound according to claim 1, which is selected from the group consisting of compounds 1 to 27, 30, 31, 37 to 70, 73, 74, 81 to 179, and 181 to 225.

68. A compound of formula (II) or a pharmaceutically acceptable salt or solvate thereof:



wherein

T represents a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, wherein group T is optionally substituted by groups (2) to (16):

(2) a halogen atom;

(3) hydroxyl;

(4) cyano group;

(5) nitro group;

(6) C1-6 alkyl;

(7) C2-6 alkenyl;

(8) C2-6 alkynyl;

(9) C1-6 alkoxy;

(10) C1-6 alkylthio;

wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

(I) hydroxyl,

(II) a halogen atom,

(III) C1-4 alkoxy,

(IV) an oxygen atom,

(V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or

(VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy,

- (11) -NR^aR^b;
 (12) -CO-OR^c;
 (13) -CO-NR^dR^e;

wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by

- (a) hydroxyl,
 (b) a halogen atom,
 (c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, and
 R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group

wherein the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom and may further contain one or more additional heteroatoms;

- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic group or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl,

two adjacent substituents on group T together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, and the carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, Q¹ and Q², which may be the same or different, represent C, S, O, or N,

X represents C or N,
 Z represents -O-, -N(-R^z)-, -S-, or -C(=O)- wherein R^z represents a hydrogen atom or unsubstituted C1-4 alkyl, R¹, R², and R⁷ to R⁹, which may be the same or different, represent,

- (1) a hydrogen atom;
 (2) a halogen atom;
 (3) hydroxyl;
 (4) cyano group;
 (5) nitro group;
 (6) C1-6 alkyl;
 (7) C2-6 alkenyl;
 (8) C2-6 alkynyl;
 (9) C1-6 alkoxy;
 (10) C1-6 alkylthio;

wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

- (I) hydroxyl,
 (II) a halogen atom,
 (III) C1-4 alkoxy,
 (IV) an oxygen atom,
 (V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4

alkyl, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy;

- (11) -NR^aR^b;
 (12) -CO-OR^c;
 (13) -CO-NR^dR^e;

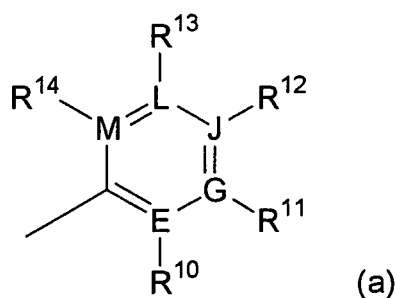
wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and C1-4 alkyl is optionally substituted by

- (a) hydroxyl,
 (b) a halogen atom,
 (c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, and R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom and may contain one or more additional heteroatoms;

- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group,

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the five-membered ring part containing Q¹ and Q² in formula (II) represents an aromatic ring, provided that, when X represents a nitrogen atom, R² is absent, and when Q¹ and Q² represent an oxygen atom or a sulfur atom, R⁷ and R⁹ which attach to the oxygen atom or the sulfur atom are absent, and, when both Q¹ and Q² represent a nitrogen atom, any one of R⁷ and R⁹ is absent.

69. The compound according to claim 68, wherein T represents a group of formula (a):



wherein

E, G, J, L, and M, which may be the same or different, represent C or N, and R¹⁰ to R¹⁴, which may be the same or different, represent

- (1) a hydrogen atom;
 (2) a halogen atom;
 (3) hydroxyl;
 (4) cyano group;
 (5) nitro group;
 (6) C1-6 alkyl;
 (7) C2-6 alkenyl;
 (8) C2-6 alkynyl;

(9) C1-6 alkoxy;
 (10) C1-6 alkylthio;
 wherein (6) C1-6 alkyl, (7) C2-6 alkenyl, (8) C2-6 alkynyl, (9) C1-6 alkoxy, and (10) C1-6 alkylthio are optionally substituted by

- (I) hydroxyl,
 (II) a halogen atom,
 (III) C1-4 alkoxy,
 (IV) an oxygen atom,
 (V) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (VI) amino group wherein one or two hydrogen atoms in the amino group are optionally substituted by C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by hydroxyl or C1-4 alkoxy;

(11) -NR^aR^b;
 (12) -CO-OR^c;
 (13) -CO-NR^dR^e;
 wherein, in groups (11) to (13), R^a, R^b, R^c, R^d, and R^e, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and the C1-4 alkyl group is optionally substituted by,

- (a) hydroxyl,
 (b) a halogen atom,
 (c) C1-4 alkoxy,
 (d) a saturated or unsaturated three- to nine-membered carbocyclic or heterocyclic group optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom, or
 (e) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, and

R^d and R^e together may combine with the carbon atoms to which they are attached represent a saturated three- to nine-membered heterocyclic group, and the heterocyclic group is optionally substituted by C1-4 alkyl, C1-4 alkoxy, or a halogen atom and may contain one or more additional heteroatoms;

- (14) a saturated or unsaturated three- to nine-membered carbocyclic group;
 (15) a saturated or unsaturated three- to nine-membered heterocyclic group; or
 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group;

wherein (14) carbocyclic group, (15) heterocyclic group, and (16) bicyclic carbocyclic group or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CQ-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, and R¹⁰ and R¹¹, R¹¹ and R¹², R¹² and R¹³, and R¹³ and R¹⁴ together may combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, and the carbocyclic group or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl, provided that, when E, G, J, L, and M represent a nitrogen atom, R¹⁰ to R¹⁴ which attach to the nitrogen atom are absent.

70. The compound according to claim 68 or 69, wherein Q¹ represents a sulfur atom, and Q² represents a carbon atom.

71. The compound according to claim 68 or 69, wherein Q¹ represents a carbon atom, and Q² represents a sulfur atom.

72. The compound according to any one of claims 69 to 71, wherein, in the group of formula (a), any one of E, G, J, L, and M represents a nitrogen atom, and all the others represent a carbon atom.

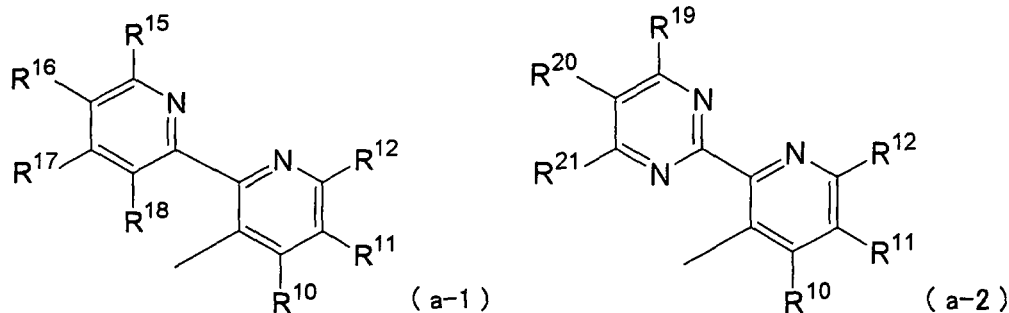
73. The compound according to claim 72, wherein L represents a nitrogen atom, and E, G, J, and M represent a carbon

atom.

74. The compound according to any one of claims 69 to 73, wherein
 R¹⁰ represents a hydrogen atom, and
 R¹¹ and R¹² are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

75. The compound according to any one of claims 69 to 74, wherein R¹⁴ represents an optionally substituted unsaturated six-membered heterocyclic group.

76. The compound according to any one of claims 69 to 75, wherein T represents a group of formula (a-1) or (a-2):



wherein

R¹⁰ to R¹² are as defined in claim 69,

R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, represent (0) a hydrogen atom, (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

77. The compound according to claim 76, wherein, in a group of formula (a-1) or (a-2), R¹⁵ to R¹⁸ and R¹⁹ to R²¹ are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

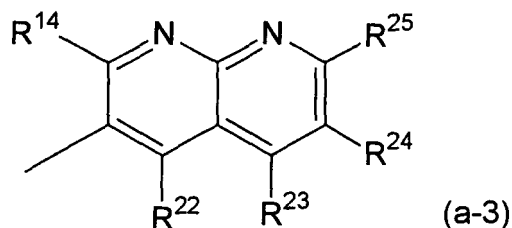
78. The compound according to claim 76, wherein
 R¹⁰ represents a hydrogen atom,
 R¹¹ and R¹² are selected from the group consisting of a hydrogen atom and C1-4 alkyl, and, in the group of formula (a-1) or (a-2), R¹⁵ to R¹⁸ and R¹⁹ to R²¹ are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

79. The compound according to claim 76, wherein
 R¹⁰ represents a hydrogen atom,
 R¹¹ and R¹² are selected from the group consisting of a hydrogen atom and C1-4 alkyl, and, in the group of formula (a-1) or (a-2), all of R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.

80. The compound according to any one of claims 76 to 79, wherein
 R¹⁰ represents a hydrogen atom, and
 R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent a saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group.

81. The compound according to claim 80, wherein R¹¹ and R¹² together combine with the carbon atoms to which they are attached represent a unsaturated six-membered carbocyclic or heterocyclic group.

82. The compound according to any one of claims 76 to 79, wherein T represents a group of formula (a-3):



wherein

R¹⁴ is as defined in claim 69,

R²² to R²⁵, which may be the same or different, represent (0) a hydrogen atom, (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

83. The compound according to claim 82, wherein, in the group of formula (a-3), R²² to R²⁵ are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

84. The compound according to claim 82, wherein, in the group of formula (a-3), all of R²² to R²⁵ represent a hydrogen atom.

85. The compound according to any one of claims 82 to 84, wherein R¹⁴ represents optionally substituted C1-4 alkyl, an optionally substituted saturated or unsaturated five- or six-membered carbocyclic or heterocyclic group, or an optionally substituted bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group.

86. The compound according to claim 85, wherein R¹⁴ represents unsubstituted C1-4 alkyl.

87. The compound according to claim 85, wherein R¹⁴ represents an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group.

88. The compound according to any one of claims 68 to 87, wherein X represents a carbon atom and both R¹ and R² represent a hydrogen atom.

89. The compound according to any one of claims 68 to 88, wherein Q¹ represents a sulfur atom, Q² represents a carbon atom, and R⁹ represents a hydrogen atom.

90. The compound according to any one of claims 68 to 88, wherein Q¹ represents a carbon atom, Q² represents a sulfur atom, and R⁷ represents a hydrogen atom.

91. The compound according to any one of claims 68 to 90, wherein both R¹ and R² represent a hydrogen atom.

92. The compound according to any one of claims 68 to 91, wherein R⁷ to R⁹, which may be the same or different, represent

(1) a hydrogen atom ;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

(9) C1-6 alkoxy;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

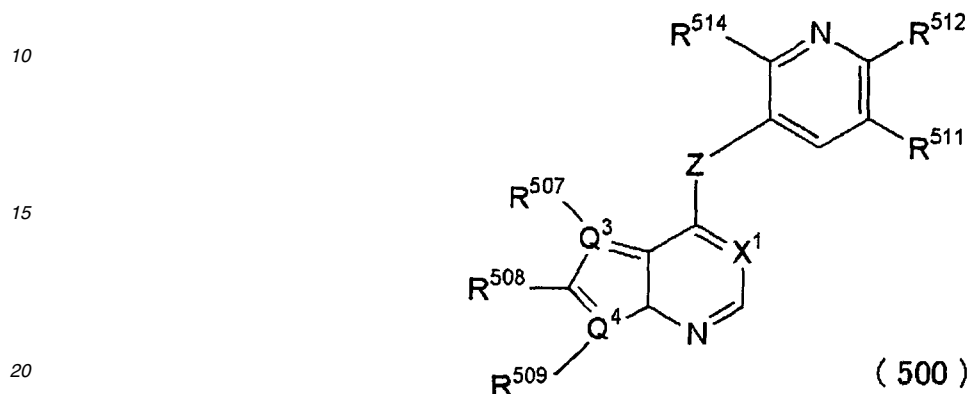
(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group, wherein these groups are optionally substituted as defined in claim 68.

93. The compound according to any one of claims 68 to 92, wherein Z represents -O-.

94. The compound according to any one of claims 68 to 93, wherein X represents a carbon atom.

5 95. The compound according to claim 68 or a pharmaceutically acceptable salt or solvate thereof, wherein formula (I) is represented by formula (500):



wherein

X¹ represents CH or N,

Z represents -O-, -NH-, -S-, or -C(=O)-,

any one of Q³ and Q⁴ represents a sulfur atom, and the other represents a carbon atom,

R⁵⁰⁷ to R⁵⁰⁹, which may be the same or different, represent

(1) a hydrogen atom ;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

(9) C1-6 alkoxy;

(12) -CO-OR^c;

(13) -CO-NR^dRe;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

(16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group wherein these groups are optionally substituted as defined in claim 68,

R⁵¹¹ and R⁵¹², which may be the same or different, are selected from the group consisting of a hydrogen atom and C1-4 alkyl,

R⁵¹⁴ represents

(14") a saturated or unsaturated five- or six-membered carbocyclic group;

(15") a saturated or unsaturated five- or six-membered heterocyclic group; or

(16") a bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group;

wherein (14") carbocyclic group, (15") heterocyclic group, and (16") bicyclic carbocyclic group or heterocyclic group are optionally substituted by (i) hydroxyl, (ii) a halogen atom, (iii) cyano group, (iv) nitro group, (v) amino group wherein one or two hydrogen atoms in the amino groups are optionally substituted by C1-4 alkyl, (vi) C1-4 alkyl, (vii) C2-4 alkenyl, (viii) C2-4 alkynyl, (ix) C1-4 alkoxy, (x) C1-4 alkylthio, (xi) -CO-OR^f, or (xii) -CO-NR^gR^h wherein R^f, R^g, and R^h, which may be the same or different, represent a hydrogen atom or C1-4 alkyl.

96. The compound according to claim 95, wherein Q³ represents a sulfur atom, and Q⁴ represents a carbon atom.

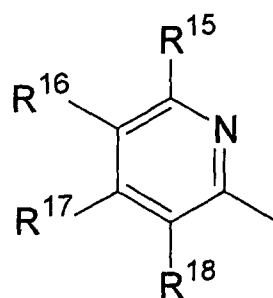
97. The compound according to claim 95, wherein Q³ represents a carbon atom, and Q⁴ represents a sulfur atom.

98. The compound according to any one of claims 95 to 97, wherein Z represents -O-.

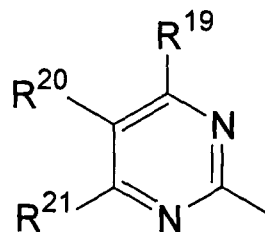
99. The compound according to any one of claims 95 to 98, wherein both R⁵¹¹ and R⁵¹² represent methyl, or R⁵¹¹

represents a hydrogen atom while R⁵¹² represents ethyl.

100. The compound according to any one of claims 95 to 99, wherein R⁵¹⁴ represents a group of formula (a-4) or formula (a-5):



(a-4)



(a-5)

wherein

R¹⁵ to R¹⁸ and R¹⁹ to R²¹, which may be the same or different, are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy.

101. The compound according to claim 100, wherein all of R¹⁵ to R¹⁸ and R¹⁹ to R²¹ represent a hydrogen atom.

102. The compound according to any one of claims 95 and 98 to 101, wherein

Q³ represents a sulfur atom,

Q⁴ represents a carbon atom,

R⁵⁰⁸ represents

a hydrogen atom,

C1-4 alkyl, or

a saturated or unsaturated six-membered carbocyclic or heterocyclic group,

wherein said carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy, and

R⁵⁰⁹ represents a hydrogen atom.

103. The compound according to claim 102, wherein R⁵⁰⁸ represents a hydrogen atom or phenyl.

104. The compound according to any one of claims 95 and 98 to 101, wherein

Q³ represents a carbon atom,

Q⁴ represents a sulfur atom, and

R⁵⁰⁷ and R⁵⁰⁸ are selected from the group consisting of a hydrogen atom and C1-4 alkyl.

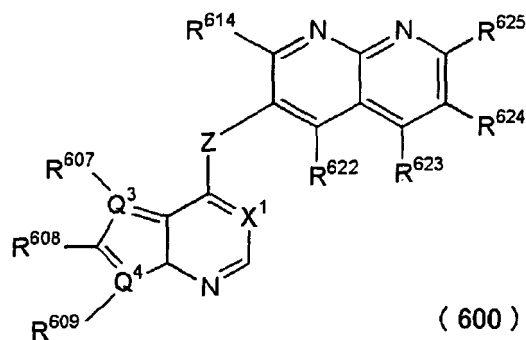
105. The compound according to claim 104, wherein

both R⁵⁰⁷ and R⁵⁰⁸ represent a hydrogen atom or

both R⁵⁰⁷ and R⁵⁰⁸ represent methyl or

R⁵⁰⁷ represent methyl while R⁵⁰⁸ represents a hydrogen atom.

106. The compound of formula (I) according to claim 69 or a pharmaceutically acceptable salt or solvate thereof, wherein formula (I) is represented by formula (600):



15 wherein

X¹ represents CH or N,

Z represents -O-, -NH-, -S-, or -C(=O)-,

any one of Q³ and Q⁴ represents a sulfur atom, and the other represents a carbon atom,

R⁶⁰⁷ to R⁶⁰⁹, which may be the same or different, represent

20 (1) a hydrogen atom ;

(2) a halogen atom;

(3) hydroxyl;

(6) C1-6 alkyl;

25 (9) C1-6 alkoxy;

(12) -CO-OR^c;

(13) -CO-NR^dRe;

(14) a saturated or unsaturated three- to nine-membered carbocyclic group;

(15) a saturated or unsaturated three- to nine-membered heterocyclic group; or

30 (16) a bicyclic saturated or unsaturated eight- to twelve-membered carbocyclic or heterocyclic group, wherein these groups are optionally substituted as defined in claim 68,

R⁶²² to R⁶²⁵, which may be the same or different, are selected from the group consisting of a hydrogen atom, a halogen atom, C1-4 alkyl, and C1-4 alkoxy, and

R⁶¹⁴ represents

35 unsubstituted C1-4 alkyl,

an optionally substituted unsaturated six-membered carbocyclic or heterocyclic group, or

an optionally substituted bicyclic saturated or unsaturated nine- or ten-membered carbocyclic or heterocyclic group.

40 **107.** The compound according to claim 106, wherein Z represents -O-.

108. The compound according to claim 106 or 107, wherein all of R⁶²² to R⁶²⁵ represent a hydrogen atom.

109. The compound according to any one of claims 106 to 108, wherein R⁶¹⁴ represents phenyl.

45 **110.** The compound according to any one of claims 106 to 108, wherein R⁶¹⁴ represents methyl or ethyl.

111. The compound according to any one of claims 106 to 110, wherein

50 Q³ represents a sulfur atom,

Q⁴ represents a carbon atom,

R⁶⁰⁸ represents

a hydrogen atom,

C1-4 alkyl, or

a saturated or unsaturated six-membered carbocyclic or heterocyclic group,

55 wherein said carbocyclic or heterocyclic group is optionally substituted by (i) hydroxyl, (ii) a halogen atom, (v') amino group, (vi') C1-2 alkyl, or (ix') C1-2 alkoxy, and

R⁶⁰⁹ represents a hydrogen atom.

112. The compound according to claim 111, wherein
 R^{608} represents a hydrogen atom or phenyl.
- 5 113. The compound according to any one of claims 106 to 110, wherein
 Q^3 represents a carbon atom,
 Q^4 represents a sulfur atom, and
 R^{607} and R^{608} are selected from the group consisting of a hydrogen atom and C1-4 alkyl.
- 10 114. The compound according to claim 113, wherein
both R^{607} and R^{608} represent a hydrogen atom or
both R^{607} and R^{608} represent methyl or
 R^{607} represents methyl while R^{608} represents a hydrogen atom.
- 15 115. The compound according to claim 68, which is selected from the group consisting of compounds 28, 29, 32 to 35,
71, 72, 75 to 78, and 180.
116. A pharmaceutical composition, comprising a compound according to any one of claims 1 to 115 or a pharmaceutically
acceptable salt or solvate thereof as an active component.
- 20 117. The pharmaceutical composition according to claim 116, which can be used for the treatment or prevention of
diseases for which TGF β inhibition is effective therapeutically or prophylactically.
118. The pharmaceutical composition according to claim 117, wherein the disease for which TGF β inhibition is effective
therapeutically or prophylactically is a disease involving organ or tissue fibrosis.
- 25 119. The pharmaceutical composition according to claim 117, wherein the disease for which TGF β inhibition is effective
therapeutically or prophylactically is chronic renal disease, acute renal disease, hepatic fibrosis, cirrhosis, plumonary
fibrosis, scleroderma, wound healing, arthritis, congestive cardiac disease, ulcer, ocular disorder, corneal problem,
diabetic nephropathy, peritoneal sclerosis, arteriosclerosis, peritoneal adhesions, or subdermal adhesion.
- 30 120. The pharmaceutical composition according to claim 117, wherein the disease for which TGF β inhibition is effective
therapeutically or prophylactically is a malignant tumor.
121. The pharmaceutical composition according to claim 116, wherein can be used for ex vivo expansion cells.
- 35 122. A TGF β inhibitor comprising a compound according to any one of claims 1 to 115 or a pharmaceutically acceptable
salt or solvate thereof as an active component.
123. A method for treating or preventing a disease for which TGF β inhibition is effective therapeutically or prophylactically,
said method comprising the step of administering a therapeutically or prophylactically effective amount of a compound
according to any one of claims 1 to 115 or a pharmaceutically acceptable salt or solvate thereof to a patient requiring
the treatment or prevention of the disease for which TGF β inhibition is effective
therapeutically or prophylactically.
- 40 124. The method according to claim 123, wherein the disease for which TGF β inhibition is effective therapeutically or
prophylactically is a disease involving organ or tissue fibrosis.
125. The method according to claim 123, wherein the disease for which TGF β inhibition is effective therapeutically or
prophylactically is chronic renal disease, acute renal disease, hepatic fibrosis, cirrhosis, plumonary fibrosis, sclero-
derma, wound healing, arthritis, congestive cardiac disease, ulcer, ocular disorder, corneal problem, diabetic ne-
phropathy, peritoneal sclerosis, arteriosclerosis, peritoneal adhesions, or subdermal adhesion.
- 50 126. The method according to claim 123, wherein the disease for which TGF β inhibition is effective therapeutically or
prophylactically is a malignant tumor.
- 55 127. A method for amplifying cells, comprising the step of adding a compound according to any one of claims 1 to 115
or a pharmaceutically acceptable salt or solvate thereof, in an amount effective for promoting cell growth, to intended
cells in vitro to amplify the cells.

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128.The method according to claim 127, wherein said intended cells are hematopoietic stem cells.

129.A method for inhibiting the action of TGF β on cells, comprising the step of applying an effective amount of a compound according to any one of claims 1 to 115 to cells present in vitro or in vivo.

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130.Use of a compound according to any one of claims 1 to 115, for the manufacture of a medicament used in the treatment or prevention of diseases for which TGF β inhibition is effective therapeutically or prophylactically.

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131.The use according to claim 130, wherein the disease for which TGF β inhibition is effective therapeutically or prophylactically is a disease involving organ or tissue fibrosis.

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132.The use according to claim 130, wherein the disease for which TGF β inhibition is effective therapeutically or prophylactically is chronic renal disease, acute renal disease, hepatic fibrosis, cirrhosis, plumonary fibrosis, scleroderma, wound healing, arthritis, congestive cardiac disease, ulcer, ocular disorder, corneal problem, diabetic nephropathy, peritoneal sclerosis, arteriosclerosis, peritoneal adhesions, or subdermal adhesion.

133.The use according to claim 130, wherein the disease for which TGF β inhibition is effective therapeutically or prophylactically is a malignant tumor.

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134.The use of a compound according to any one of claims 1 to 115, for the manufacture of a TGF β inhibitor.

135.The use of a compound according to any one of claims 1 to 115, for the manufacture of a promotor forex vivo expansion cells.

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/002610

<p>A. CLASSIFICATION OF SUBJECT MATTER Int.Cl⁷ C07D401/14, 409/14, 405/14, 417/14, 471/04, 495/04, 519/00, 215/22, 239/88, 401/12, 405/12, 413/12, A61K31/4375, 31/444, A61P1/04, 1/16 According to International Patent Classification (IPC) or to both national classification and IPC</p>											
<p>B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl⁷ C07D401/14, 409/14, 405/14, 417/14, 471/04, 495/04, 519/00, 215/22, 239/88, 401/12, 405/12, 413/12, A61K31/4375, 31/444, A61P1/04, 1/16 Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched</p>											
<p>Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) CAPLUS (STN), REGISTRY (STN), MEDLINE (STN), CHEMCAST (STN)</p>											
<p>C. DOCUMENTS CONSIDERED TO BE RELEVANT</p> <table border="1"> <thead> <tr> <th>Category*</th> <th>Citation of document, with indication, where appropriate, of the relevant passages</th> <th>Relevant to claim No.</th> </tr> </thead> <tbody> <tr> <td>X</td> <td> JP 2001-500890 A (Zenaca Ltd.), 23 January, 2001 (23.01.01), Claims; examples & WO 98/13350 A1 & AU 9743137 A & NO 9901423 A & NZ 334125 A & EP 929526 A1 & CN 1237963 A & MX 9902796 A1 & KR 2000/048575 A </td> <td> 1-9, 15-16, 23-29, 44-47, 116-122, 130-135 </td> </tr> <tr> <td>X</td> <td> WO 2003/033472 A1 (Kirin Brewery Co., Ltd.), 24 April, 2003 (24.04.03), Claims; examples & EP 1447405 A1 & AU 2002/343997 A1 & JP 2003-536212 A & US 2005/049264 A1 </td> <td> 1, 7-9, 23, 26-29, 44-47, 116-122, 130-135 </td> </tr> </tbody> </table>			Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.	X	JP 2001-500890 A (Zenaca Ltd.), 23 January, 2001 (23.01.01), Claims; examples & WO 98/13350 A1 & AU 9743137 A & NO 9901423 A & NZ 334125 A & EP 929526 A1 & CN 1237963 A & MX 9902796 A1 & KR 2000/048575 A	1-9, 15-16, 23-29, 44-47, 116-122, 130-135	X	WO 2003/033472 A1 (Kirin Brewery Co., Ltd.), 24 April, 2003 (24.04.03), Claims; examples & EP 1447405 A1 & AU 2002/343997 A1 & JP 2003-536212 A & US 2005/049264 A1	1, 7-9, 23, 26-29, 44-47, 116-122, 130-135
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.									
X	JP 2001-500890 A (Zenaca Ltd.), 23 January, 2001 (23.01.01), Claims; examples & WO 98/13350 A1 & AU 9743137 A & NO 9901423 A & NZ 334125 A & EP 929526 A1 & CN 1237963 A & MX 9902796 A1 & KR 2000/048575 A	1-9, 15-16, 23-29, 44-47, 116-122, 130-135									
X	WO 2003/033472 A1 (Kirin Brewery Co., Ltd.), 24 April, 2003 (24.04.03), Claims; examples & EP 1447405 A1 & AU 2002/343997 A1 & JP 2003-536212 A & US 2005/049264 A1	1, 7-9, 23, 26-29, 44-47, 116-122, 130-135									
<p><input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.</p>											
<p>* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family</p>											
<p>Date of the actual completion of the international search 17 March, 2005 (17.03.05)</p>		<p>Date of mailing of the international search report 05 April, 2005 (05.04.05)</p>									
<p>Name and mailing address of the ISA/ Japanese Patent Office</p>		<p>Authorized officer</p>									
<p>Facsimile No.</p>		<p>Telephone No.</p>									

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/002610

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
P,X	WO 2004/018430 A1 (Kirin Brewery Co., Ltd.), 04 March, 2004 (04.03.04), Claims; examples & AU 2003/257666 A1	1,7-29, 44-67, 116-122, 130-135
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X	YAGI M. et al., "Selective Inhibition of Platelet-Derived Growth Factor (PDGF) Receptor Autophosphorylation and PDGF-Mediated Cellular Events by a Quinoline Derivative", 1997, Vol.234, pages 285 to 292	1,7-9,23, 26-29,44-47
X	JP 01-246263 A (Eli Lilly and Co.), 02 October, 1989 (02.10.89), Claims; examples & EP 326330 A1 & AU 8928728 A & BR 8900356 A & FI 8900423 A & ZA 8900626 A & CN 1034925 A	1,7-9,23, 26-29,44-47
X	JP 2002-536414 A (Astra Zeneca AB.), 29 October, 2002 (29.10.02), Claims; examples & WO 2000/47212 A1 & AU 2000/24475 A & NO 2001/03882 A & EP 1154774 A1 & BR 2000/08128 A & KR 2001/102044 A	1,7-9,27-28, 44-47, 116-122, 130-135
X	JP 2000-515114 A (Zenaca Ltd.), 14 November, 2000 (14.11.00), Claims; examples & WO 97/22596 A1 & AU 9711061 A & EP 873319 A1 & BR 9612043 A & CN 1205694 A & US 5962458 A & KR 2000/064455 A	1,7-9,27-28, 44-47, 116-122, 130-135
X	WO 95/15758 A1 (ROHNE POULENC ROBER PHARMACEUTICAL INC.), 15 June, 1995 (15.06.95), Claims; examples & AU 9513050 A & US 5480883 A & EP 871448 A1	1,7-9,27-28, 44-47, 116-122, 130-135
X	WO 95/24190 A2 (SUGEN, INC.), 14 September, 1995 (14.09.95), Claims; examples & AU 9520968 A	1,7-9,27-28, 44-47, 116-122, 130-135

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INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP2005/002610

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2001/02409 A1 (VERNALIS RESEARCH LTD.), 11 January, 2001 (11.01.01), Claims; examples & AU 2000/55578 A & EP 1192164 A1 & JP 2003-503504 A	68-70, 72-75, 89, 91-93, 116-122, 130-135
X	JP 04-217685 A (BASF AG.), 07 August, 1992 (07.08.92), Claims; examples & EP 447891 A1 & DE 4008726 A & CA 2038521 A	68-70, 72-75, 89, 91-93, 116-122, 130-135

Form PCT/ISA/210 (continuation of second sheet) (January 2004)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2005/002610

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.: 123 - 129
because they relate to subject matter not required to be searched by this Authority, namely:
Claims 123 to 129 pertain to methods for treatment of the human body by surgery or therapy and diagnostic methods.
2. Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
3. Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest The additional search fees were accompanied by the applicant's protest.
 No protest accompanied the payment of additional search fees.

REFERENCES CITED IN THE DESCRIPTION

This list of references cited by the applicant is for the reader's convenience only. It does not form part of the European patent document. Even though great care has been taken in compiling the references, errors or omissions cannot be excluded and the EPO disclaims all liability in this regard.

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