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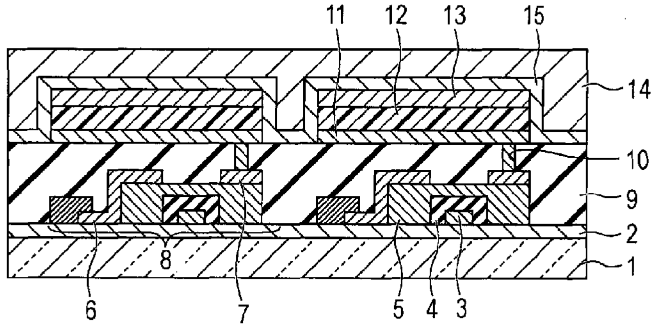
(54) Title: ORGANOMETALLIC COMPLEX AND ORGANIC LIGHT EMITTING ELEMENT INCLUDING THE SAME

FIGURE 1



(57) **Abstract**: The present invention provides an organometallic complex useful as a guest material of a blue phosphorescent light emitting element. In addition, the present invention also provides an organic light emitting element having a high luminescent efficiency. An organometallic complex according to Claim 1 represented by the general formula [1] is provided. In the general formula [1], R_1 to R_7 are each independently selected from a hydrogen atom and an alkyl group. The alkyl group indicates an alkyl group having 1 to 4 carbon atoms. A sulfone group and an ether group in the general formula [1] may bond to each other so as to form a five-membered ring or a six-membered ring.

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DESCRIPTION

ORGANOMETALLIC COMPLEX AND ORGANIC LIGHT EMITTING ELEMENT INCLUDING THE SAME

Technical Field

[0001] The present invention relates to an organometallic complex and an organic light emitting element including the same.

Background Art

[0002] An organic light emitting element is an element which includes a pair of electrodes and an organic compound layer arranged therebetween. When electrons and holes are injected from the pair of electrodes, excitons of a luminescent organic compound in the organic compound layer are generated, and when the excitons return to the ground state, light is emitted.

[0003] In recent years, as an attempt to improve the luminescent efficiency of the organic light emitting element, development of an organic light emitting element which uses phosphorescent light emission through triplet excitons has been actively performed. The organic light emitting element using phosphorescent light emission is expected to have an improved luminescent efficiency approximately four times higher than that of fluorescent light emission.

[0004] As a phosphorescent compound as described above, for example, in PTL 1, an iridium complex including a phenylpyridine ligand which has a trifluoromethyl group has been disclosed.

[0005] In addition, in PTL 2, an iridium complex in which two fluorinated phenylpyridine ligands and two types of monodentate ligands are coordinated has been disclosed.

[0006] As for a technique of shortening the emission wavelength, besides the techniques described above, that is, the introduction of a fluorine atom or a trifluoromethyl group in the phenylpyridine ligand, techniques for introducing electron withdrawing groups, such as a cyano group and a sulfone group, have also been proposed.

[0007] In addition, in NPL 1, an organometallic complex in which a sulfone group is introduced has been disclosed. This organometallic complex is an iridium complex in which phenylpyridine having a sulfone group bonded to its benzene ring and acetylacetone are coordinated.

Citation List

Patent Literature

[0008] PTL 1 PCT Japanese Translation Patent Publication No. 2004-503059

PTL 2 Japanese Patent Laid-Open No. 2005-139185

Non Patent Literature

[0009] NPL 1 Chemistry-A European Journal vol. 15, No. 1, pp. 136 to 148 (2009)

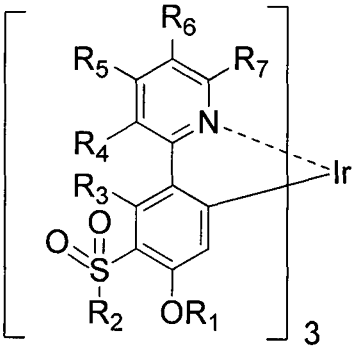
[0010] The iridium complex disclosed in PTL 1 has a slightly long emission wavelength and cannot be used as a blue luminescent material. The iridium complex disclosed in PTL 2 has not enough luminescent efficiency. The present invention provides an organometallic complex which emits light in a blue region and which has a high luminescent efficiency.

Summary of Invention

[0011] Therefore, the present invention provides an organometallic complex represented by the following general formula [1].

[0012]

[Chem. 1]



[1]

[0013] In the general formula [1], R_1 to R_7 are each independently selected from a hydrogen atom and an alkyl group. The alkyl group indicates an alkyl group having 1 to 4 carbon atoms. A sulfone group and an ether group of the general formula [1] may bond to each other to form a five-membered ring or a six-membered ring.

[0014] According to the present invention, an organometallic complex having a high luminescent efficiency can be provided. In addition, an organic light emitting element which includes the above organometallic complex and which has a high luminescent efficiency can be provided.

Brief Description of Drawing

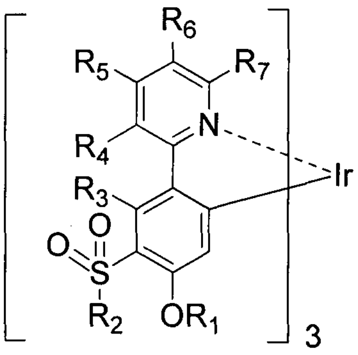
[0015] Figure 1 is a schematic cross-sectional view showing an organic light emitting element and a switching element connected thereto.

Description of Embodiments

[0016] The present invention provides an organometallic complex represented by the following general formula [1].

[0017]

[Chem. 2]



[1]

[0018] In the general formula [1], R_1 to R_7 are each independently selected from a hydrogen atom and an alkyl group. The alkyl group indicates an alkyl group having 1 to 4 carbon atoms. The alkyl group having 1 to 4 carbon atoms indicates a methyl group, an ethyl group, a n-propyl group, an iso-propyl group, a n-butyl group, an iso-butyl group, a sec-butyl group, or a tert-butyl group.

[0019] The ether group and the sulfone group adjacent thereto of the general formula [1] may bond to each other to form a five-membered ring or a six-membered ring. That is, R_1 and R_2 bond to each other to form a five-membered ring or a six-membered ring. When a five-membered ring is formed, R_1 and R_2 collectively represent one carbon atom.

Properties of Organometallic Complex of the Present Invention

[0020] Since the phenyl group in the molecular structure has a sulfone group and an alkoxy group, the organometallic complex of the present invention has a short emission wavelength and a high luminescent efficiency.

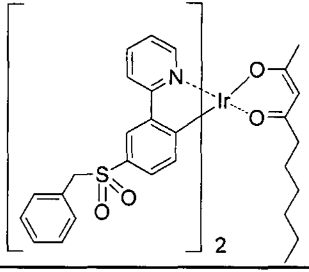
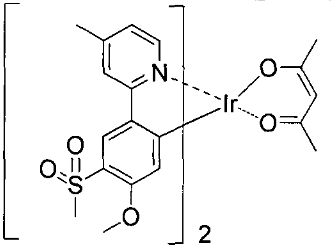
[0021] In this embodiment, the blue region indicates light having a wavelength of 450 to 480 nm.

[0022] In NPL 1, the organometallic complex which uses phenylpyridine having a sulfone group and diketone as ligands has been disclosed.

[0023] The emission wavelength (actual measurement value) of the organometallic complex described in NPL 1 is shown in the following Table 1. The compound indicated by 4-SO2R is the organometallic complex described in NPL 1, and the compound indicated by a is a compound prepared for comparison with the present invention.

[0024]

[Table 1]

COMPOUND	STRUCTURE	EMISSION WAVELENGTH (CH_2Cl_2 SOLUTION)
4-SO2R		498nm
a		480nm

[0025] In the compound described in NPL 1, although having a sulfone group, the phenyl group in the molecular structure has no alkoxy group.

[0026] On the other hand, the organometallic complex indicated by a has both a sulfone group and an alkoxy group.

[0027] In Table 1, the emission wavelength of 4-SO2R is 498 nm.

[0028] In the organometallic complex indicated by a, a methoxy group is provided at the 5-position adjacent to a sulfone group, so that the emission wavelength is shortened.

[0029] The emission wavelength of the organometallic complex indicated by a is 480 nm and is shortened by 18 nm as compared to that of 4-SO2R.

[0030] The reason for this is believed that in addition to the electron withdrawing effect of the sulfone group at the 4-position, the methoxy group having an electronic withdrawing property is provided at the 5-position.

[0031] The compound of the present invention is an organometallic complex having three ligands each identical to each of the two ligands of the organometallic complex indicated by a.

[0032] That is, in the compound of the present invention, since the number of the sulfone groups and the number of the methoxy groups are larger than those of the compound indicated by a, the emission wavelength is shortened.

[0033] Since the organometallic complex of the present invention has three phenylpyridine ligands each including both a sulfone group and an alkoxy group, blue light emission with a high luminescent efficiency can be obtained.

[0034] Since the organometallic complex of the present invention has a high quantum yield of light emission in a solution, when this organometallic complex is used as a constituent material of an organic light emitting element, the organic light emitting element can be expected to have a high luminescent efficiency.

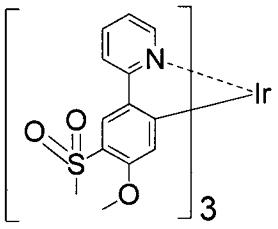
[0035] Therefore, when the organometallic complex of the present invention is used as a luminescent material, a blue organic light emitting element having a high color purity and a high efficiency can be obtained.

Examples of Organic Compound of the Present Invention

[0036] Particular examples of the organometallic complex of the present invention will be shown below. However, the present invention is not limited thereto.

[0037]

[Chem. 3]



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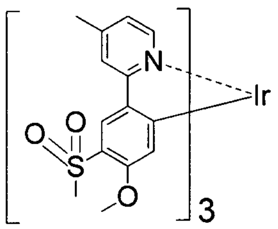

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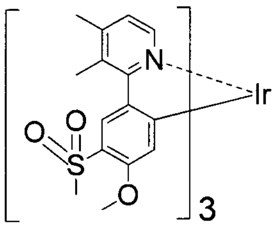

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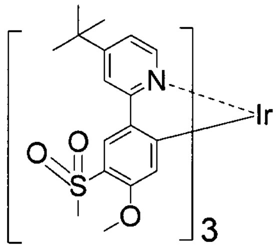

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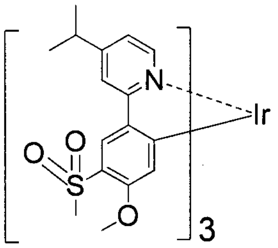

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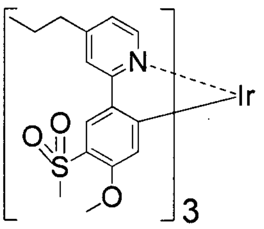

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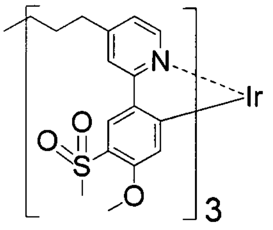

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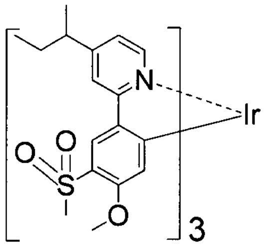

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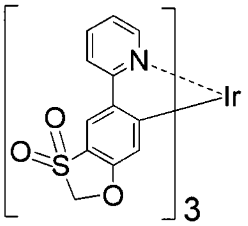

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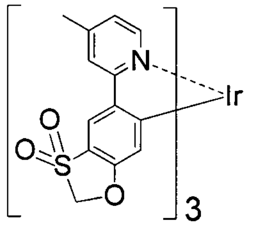

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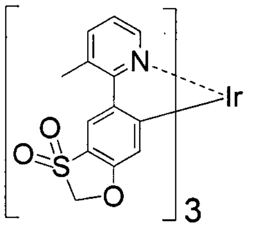

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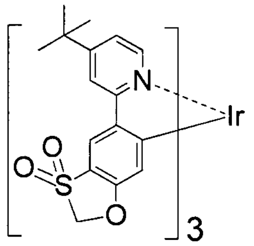

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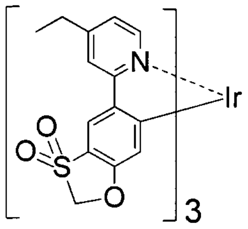

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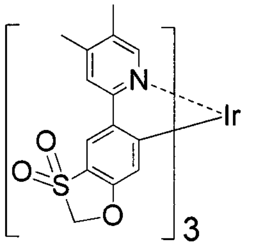

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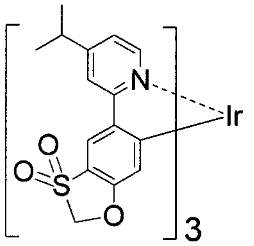

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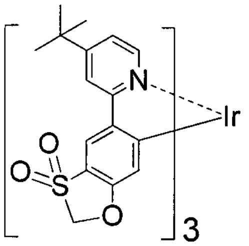

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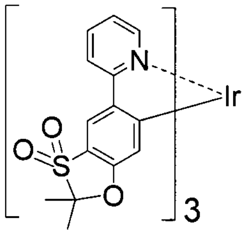

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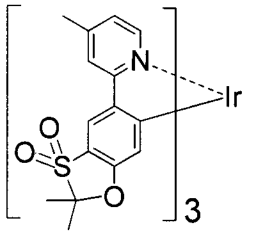

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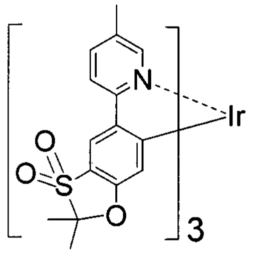

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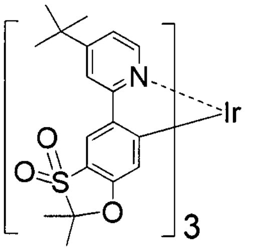

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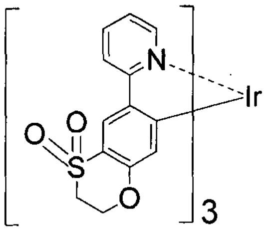
[0038]

[Chem. 4]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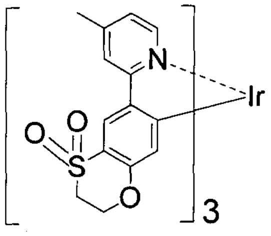
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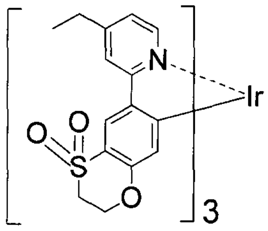
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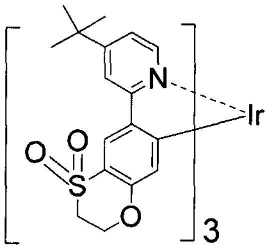
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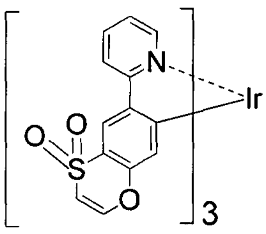
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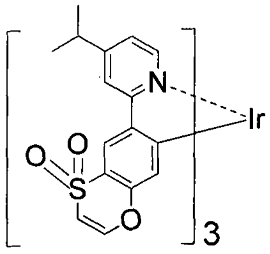
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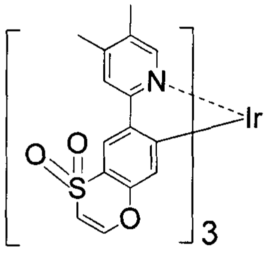
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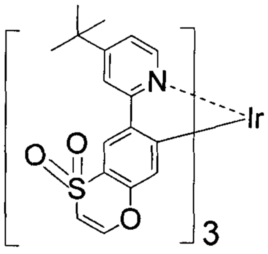
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Description of Synthetic Route

[0039] One example of a synthetic route of the compound of the present invention will be described. The organometallic complex represented by the general formula [1] may be synthesized, for example, with reference to PCT Japanese Translation Patent Publication No. 2008-543971, Journal of Medicinal Chemistry, vol. 24, No. 11, pp. 1348 to 1353, (1981), Inorganic Chemistry, vol. 40, No. 7, pp. 1704 to 1711, (2001), Journal of Heterocyclic Chemistry, vol. 19, No. 1, pp. 135 to 139, (1982). In particular, the synthesis can be performed through the following steps.

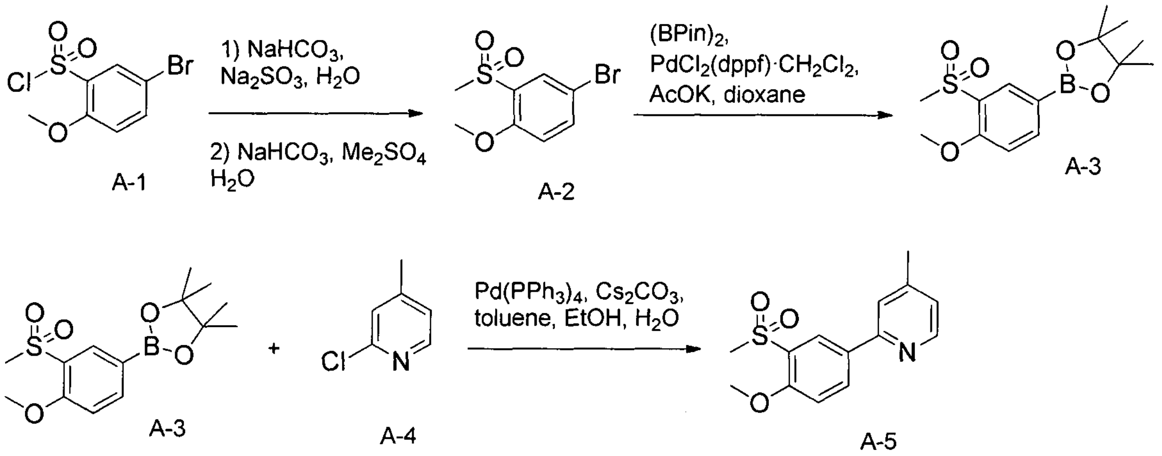
(i) Synthesis of Organic Compound used as Ligand

(ii) Synthesis of Organometallic Complex

[0040] In this embodiment, for example, the organic compound used as the ligand may be synthesized as described below.

[0041]

[Chem. 5]



[0042] The ligand is obtained by processing a compound A-1 with dimethyl sulfate under a basic condition. A compound A-3 is obtained, for example, when a compound A-2 and bispinacolborane react with each other in the presence of a Pd catalyst. A compound A-5 can be obtained when a compound A-4 react with a pinacolborane compound A-3 in the presence of $Pd(PPh_3)_4$ as a catalyst and sodium carbonate in a mixed solvent of toluene, ethanol, and distilled water.

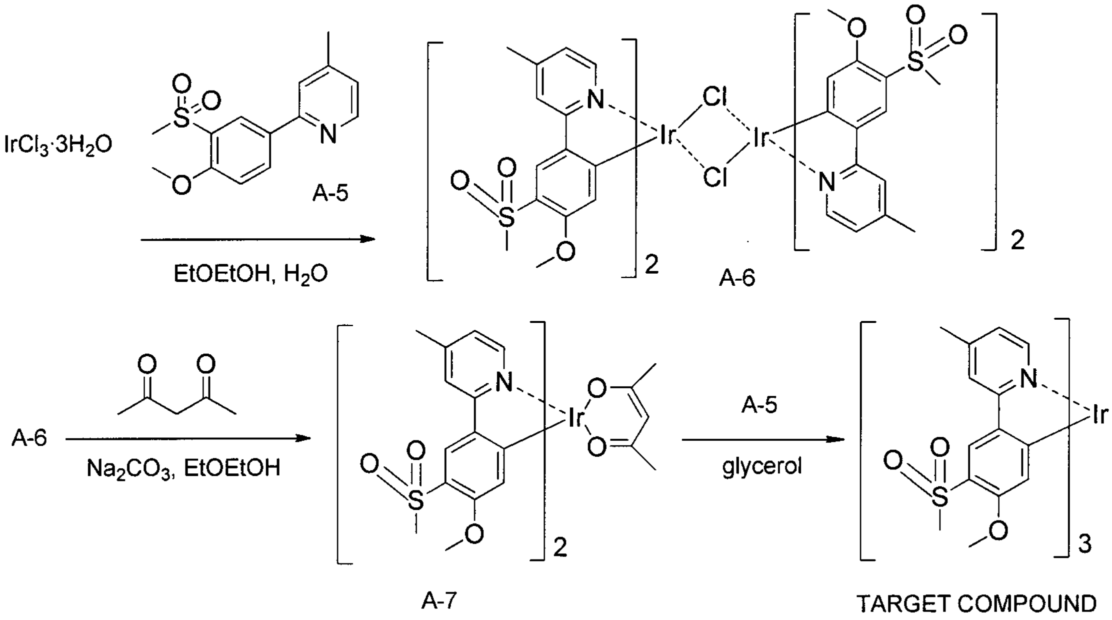
[0043] In addition, various organic compounds can be synthesized when the compound A-4 is changed.

[0044] The organometallic complex of the present invention can be synthesized by the following synthetic method using the ligand synthesized, for example, by the above synthetic route.

[0045] The iridium complex is synthesized through the following three stages.

[0046]

[Chem. 6]



Description of Organic Light Emitting Element according to this Embodiment

[0047] Next, an organic light emitting element according to this embodiment will be described.

[0048] The organic light emitting element according to this embodiment is an organic light emitting element which includes a pair of electrodes, an anode and a cathode, facing each other and at least one organic compound layer arranged therebetween.

[0049] A layer having a phosphorescent material among the organic compound layers is a light emitting layer. In addition, in the organic light emitting element of the present invention, the above organic compound layer contains the organometallic complex represented by the general formula [1].

[0050] In the organic light emitting element according to this embodiment, the number of the organic compound layers may be one or two or more. The plurality of layers are layers appropriately selected from a hole injection layer, a hole transport layer, an electron blocking layer, a light emitting layer, a hole blocking layer, an electron transport layer, an electron injection layer, an exciton diffusion blocking layer, and the like.

[0051] Of course, a plurality of layers may be selected from the above group and may be used in combination. For example, an organic light emitting element which has a pair of electrodes, a hole injection layer, a hole transport layer, a light emitting layer, an electron transport layer, and an electron injection layer may be mentioned.

[0052] In addition, a plurality of light emitting layers may be provided so that respective elements emit different types of color light.

[0053] A light emitting element having a plurality of light emitting layers may have a plurality of light emitting layers between a pair of electrodes. For example, there may be mentioned a structure in which light emitting layers respectively emitting red, green, and blue light are laminated between an anode and a cathode.

[0054] However, the structure of the organic light emitting element according to this embodiment is not limited thereto. For example, there may be used various layer structures in which an insulating layer is provided at the interface between the electrode and the organic compound layer, in which an adhesion layer or an interference layer is provided, and in which the electron transport layer or the hole transport layer is formed from two layers having different ionization potentials.

[0055] As element configurations in the cases described above, any one of a so-called top emission method in which light is extracted from a side opposite to the substrate, a so-called bottom emission method in which light is extracted from a substrate side, and a dual extraction method may be used.

[0056] In the organic light emitting element according to this embodiment, when a plurality of organic compound layers is provided, the organometallic complex may be contained in any layer thereof. For example, the hole injection layer, the hole transport layer, the light emitting layer, the hole blocking layer, or the electron transport layer may be used. The light emitting layer is preferably selected.

[0057] Although the light emitting layer of the organic light emitting element according to this embodiment may be formed from only the organometallic compound of the present invention, a host material and a guest material are preferably contained. Furthermore, an assistant material may also be contained.

[0058] In this case, the host material is a compound having the highest weight ratio in the light emitting layer, functioning as a matrix, and being primarily responsible to transport carriers and to supply excitation energy to the guest.

[0059] The guest material is a compound which has a weight ratio smaller than that of the host material in the light emitting layer and which is responsible for primary light emission.

[0060] The assistant material is a compound which has a weight ratio smaller than that of the host material in the light emitting layer and which assists light emission of the guest material. The assistant material may also be called a second host material or a host material 2 in some cases.

[0061] In addition, when the organometallic complex according to this embodiment is used as the guest material, the concentration of the guest material to the whole light emitting layer is preferably 0.1 to 30 percent by weight and more preferably 0.5 to 10 percent by weight.

[0062] Besides the organometallic complex of the present invention, the organic light emitting element according to this embodiment may also use a known low molecular and/or high molecular compound, if needed.

[0063] Examples of these compounds are shown below.

[0064] As a hole injection material or a hole transport material, a material having a high hole mobility is preferably used. As a low molecular and a high molecular material having a hole injection ability or a hole transport ability, for example, a triarylamine derivative, a phenylenediamine derivative, a stilbene derivative, a phthalocyanine derivative, a porphyrin derivative, a poly (vinyl carbazole), a poly(thiophene), and other conductive polymers may be mentioned; however, of course, the low molecular and the high molecular materials are not limited thereto.

[0065] As the host material, for example, a triarylamine derivative, a carbazole derivative, a phenylene derivative, a condensed ring aromatic compound (such as a fluorene derivative, a benzene derivative, or a triphenylene derivative), an organometallic complex (such as an organic aluminum complex including tris(8-quinolinolato)aluminum, an organic beryllium complex, an organic iridium complex, or an organic platinum complex), and a polymer derivative, such as a poly(phenylene vinylene) derivatives, a poly(fluorene) derivative, a poly(phenylene) derivative, a poly(thienylene vinylene) derivative, or a poly(acetylene) derivative, may be mentioned; however, of course, the host material is not limited thereto. As the host material, a compound having a triphenylene derivative is particularly preferable.

[0066] The triphenylene derivative is a compound having a triphenylene skeleton in its molecular structure.

[0067] An electron injection material or an electron transport material is selected, for example, in consideration of the balance with the hole mobility of the hole injection material or the hole transport material. As the material having an electron injection ability or an electron transport ability, for example, an oxadiazole derivative, an oxazole derivative, a pyridine derivative, a triazole derivative, a triazine derivative, a quinoline derivative, a quinoxaline derivative, a phenanthroline derivative, and an organic aluminum complex may be mentioned; however, of course, the above material having an electron injection ability or an electron transport ability is not limited thereto. Furthermore, an alkali metal, such as lithium or cesium, an alkaline earth metal, such as calcium, or a doped salt thereof may also be used.

[0068] As an anode material, a material having a work function as high as possible is preferable. For example, metals, such as gold, platinum, silver, copper, nickel, palladium, cobalt, selenium, vanadium, and tungsten, alloys formed from the metals mentioned above, and metal oxides, such as tin oxide, zinc oxide, indium oxide, indium tin oxide (ITO), and indium zinc oxide, may be used. In addition, conductive polymers, such as a polyaniline, a polypyrrole, and a polythiophene, may also be used. These electrode materials may be used alone, or at least two types thereof may be used in combination. In addition, the anode may be formed either from a single layer or a plurality of layers.

[0069] On the other hand, as a cathode material, a material having a low work function is preferably used. For example, an alkali metal, such as lithium or cesium, an alkaline earth metal such as calcium, and a metal, such as aluminum, titanium, manganese, silver, lead, or chromium, may be mentioned. Alternatively, alloys formed from those metals in combination may also be used. For example, magnesium-silver, aluminum-lithium, and aluminum-magnesium may be used. Metal oxides, such as indium tin oxide (ITO), may also be used. These electrode materials may be used alone, or at least two types thereof may be used in combination. In addition, the cathode may be formed either from a single layer or a plurality of layers.

[0070] In the organic light emitting element according to this embodiment, the layer including the organometallic complex according to this embodiment and the layer including the other organic compound are formed by the following methods.

[0071] In general, the layer is formed by a vacuum deposition method, an ionization deposition method, a sputtering method, a plasma deposition method, or a known coating method (such as spin coating, dipping, a casting method, an LB method, or an ink jet method) using an organic compound dissolved in an appropriate solvent.

[0072] When the layer is formed, for example, by a vacuum deposition method or a solution coating method, for example, crystallization is not likely to occur, and a film having excellent aging stability is obtained. In addition, when a coating method is used for film formation, a film may also be formed in combination with a suitable binder resin.

[0073] As the binder resin mentioned above, although a poly(vinyl carbazole) resin, a polycarbonate resin, a polyester resin, an ABS resin, an acrylate resin, a polyimide resin, a phenol resin, an epoxy resin, a silicone resin, a urea resin, and the like may be mentioned, the binder resin is not limited thereto.

[0074] In addition, as the binder resin, a homopolymer or a copolymer may only be used, or at least two types thereof may also be used in combination. Furthermore, additives, such as a known plasticizer, antioxidant, and ultraviolet absorber, may also be used, if needed.

Application of Organic Light Emitting Element according to this Embodiment

[0075] The organic light emitting element according to this embodiment may be used for a display device and a lighting device. In addition, the organic light emitting element according to this embodiment may also be used, for example, for an exposure light source of an image forming device of an electrophotographic system and a backlight of a liquid crystal display device.

[0076] The display device has the organic light emitting element according to this embodiment in a display portion. This display portion includes a plurality of pixels. The pixels each have the organic light emitting element according to this embodiment and a TFT element as one example of a switching element controlling the luminescent brightness.

[0077] The switching element is connected to the anode or the cathode of this organic light emitting element and a drain electrode or a source electrode of the thin film transistor.

[0078] The display device may be used as an image display device of a personal computer (PC), a head mount display, a mobile phone, or the like. As an image to be displayed, any image, such as a two-dimensional image or a threedimensional image, may be displayed.

[0079] The display device may be an image output device which has an input portion to input image information from an area CCD, a linear CCD, a memory card, or the like, and which outputs an inputted image on the display portion.

[0080] The image output device may be a digital camera having an imaging optical system in which the image input portion is formed of an image sensor, such as a CCD sensor.

[0081] The display device may have an input function which can perform an input by touching an output image. For example, a touch-panel function may be mentioned.

[0082] In addition, the display device may be used for a display portion of a multifunctional printer.

[0083] The organic light emitting element according to this embodiment may also be used for a lighting device. This lighting device has the organic light emitting element according to this embodiment and an inverter circuit connected thereto.

[0084] The color of light emitted from the lighting device according to this embodiment may be white, natural white, and any other colors.

[0085] In the case of white and natural white, the lighting device may also have a compound besides the compound according to this embodiment. That is, white and natural white may be a color obtained by mixing a luminescent color of the compound different from that of the compound according to this embodiment.

[0086] Next, the display device having the organic light emitting elements according to this embodiment will be described with reference to Figure 1.

[0087] Figure 1 is a schematic cross-sectional view showing the organic light emitting element according to this embodiment and a TFT element, which is one example of a switching element, connected the above organic light emitting element. In this figure, two sets each including the organic light emitting element and the TFT element are shown. Hereinafter, the structure will be described in detail.

[0088] The display device shown in Figure 1 includes a substrate 1 formed of a glass or the like and a dampproof film 2 provided thereon to protect the TFT element or the organic compound layer. In addition, reference numeral 3 indicates a metal gate electrode. Reference numeral 4 indicates a gate insulating film, and reference numeral 5 indicates a semiconductor layer.

[0089] A thin film transistor 8 includes the semiconductor layer 5, a drain electrode 6, and a source electrode 7. An insulating film 9 is provided on an upper portion of the thin film transistor 8, and an anode 11 of the organic light emitting element and the source electrode 7 are connected to each other through a contact hole 10.

[0090] The display device is not limited to that described above and may have any structure as long as the anode or the cathode is connected to one of the source electrode and the drain electrode of the thin film transistor.

[0091] Since this figure is simplified, an organic compound layer 12 is shown as one layer; however, a plurality of organic compound layers may be provided. On the cathode 13, a first protective layer 14 and a second protective layer 15 are provided to suppress degradation of the organic light emitting element.

[0092] In the display device according to this embodiment, the switching element is not particularly limited, and a transistor or an MIM element may be used. As the transistor, for example, a thin film transistor using single crystal silicon or an amorphous-silicon type transistor element may be used. The thin film transistor is also called a TFT element.

[0093] The luminescent brightness of the organic light emitting element is controlled by the switching element. When a plurality of organic light emitting elements is provided on the plane, an image can be displayed by the luminescent brightness of each organic light emitting element.

[0094] In addition, the control may also be performed in such a way that active matrix drivers are formed on a Si substrate, and the organic light emitting elements are provided thereon.

[0095] The structure may be selected depending on the fineness, and for example, when the fineness is approximately QVGA, the structure in which organic light emitting elements are provided on a Si substrate is preferable.

[0096] When the display device using the organic light emitting elements according to this embodiment is driven, stable display with excellent image quality can be performed for a long time.

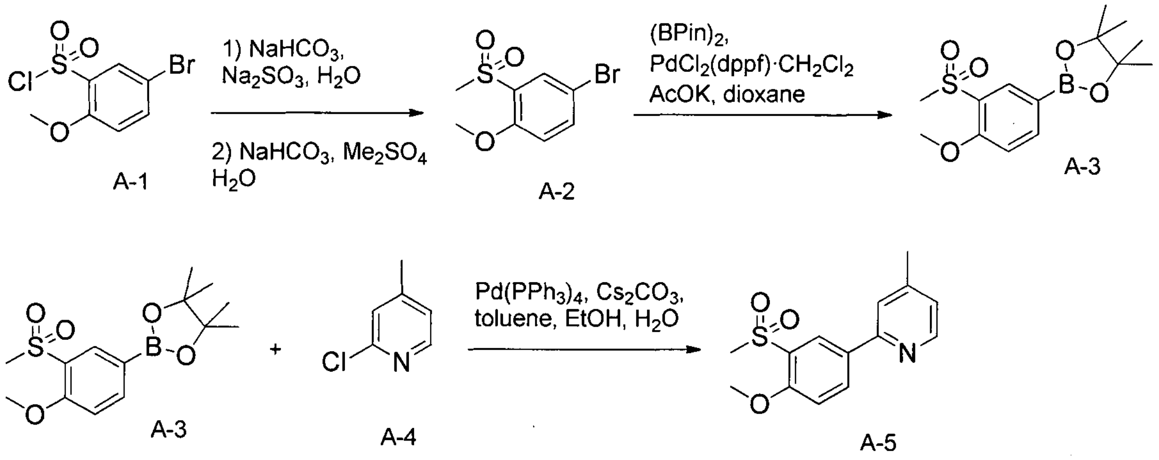
Examples

Example 1

Synthesis of Example Compound (2)

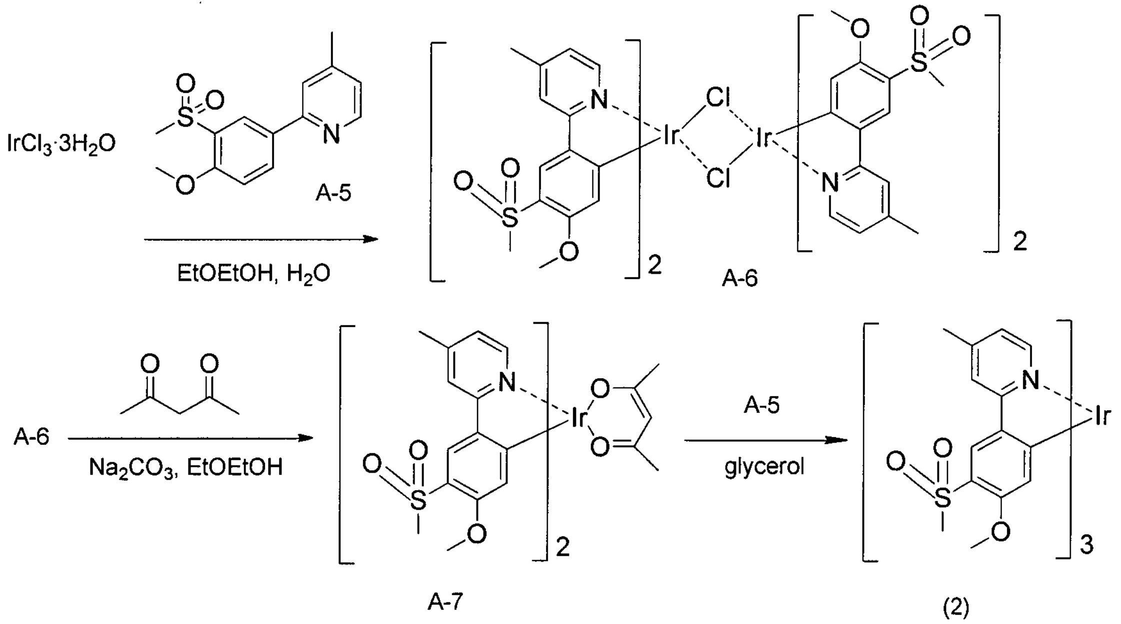
[0097]

[Chem. 7]



[0098]

[Chem. 8]



(1) Synthesis of Compound A-2

[0099] The following reagents and solvent were charged in a reaction vessel.

Sodium sulfite: 4.14 g (32.8 mmol)

Sodium hydrogencarbonate: 2.90 g (34.5 mmol)

Water: 18 ml

[0100] This suspension was stirred at 80°C, and the compound A-1 (sulfonyl chloride: 5.0 g, 17.5 mmol) was slowly added over 20 minutes. After stirring was performed at 80°C for 6 hours, stirring was performed at room temperature for 16 hours. A precipitated solid was recovered by filtration and was then dried under high vacuum conditions. The dried solid (4.8 g) was added to a mixed solution of sodium hydrogencarbonate (2.90 g, 33.3 mmol), dimethyl sulfate (2.5 ml, 26.3 mmol), and water (6.5 ml). After being heated at 120°C for 8 hours, this suspension was cooled to room temperature and was transferred to a separating funnel, and after water was added thereto, extraction was performed with ethyl acetate. An organic layer was washed with a saturated salt solution and was then dried with sodium sulfate. The solvent was condensed under reduced pressure, so that a target compound, the compound A-2 (3.21 g, 69%), was obtained.

(2) Synthesis of Compound A-3

[0101] The following reagents and solvent were charged in a reaction vessel.

Compound A-2: 2.50 g (9.43 mmol)
Bispinacoldiborane: 3.59 g (14.1 mmol)
$PdCl_2(dppf)\cdot CH_2Cl_2$: 385 mg (0.47 mmol)
Potassium acetate: 2.78 g (28.3 mmol)
Dioxane: 40 ml

[0102] Under a nitrogen stream, this suspension was stirred at 90°C for 8 hours and was then cooled to room temperature. After an inorganic material was removed by celite filtration, washing was performed with ethyl acetate. After the filtrate was condensed under reduced pressure, the residue was refined by a silica gel column chromatography (mobile phase; heptane: ethyl acetate=2: 1), so that 1.94 g of the compound A-3 (yield: 66%) was obtained.

(3) Synthesis of Compound A-5

[0103] The following reagents and solvents were charged in a reaction vessel.

Compound A-3: 1.60 g (5.13 mmol)

Compound A-4: 654 mg (5.13 mmol)

Toluene: 30 ml

Ethanol: 10 ml

Cesium carbonate aqueous solution at a concentration of 10 percent by weight: 20 ml

[0104] After tetrakis(triphenylphosphine)palladium(0) (296 mg, 0.26 mmol) was added to this reaction solution, this mixture was heated to 90°C and stirred for 7 hours. After cooling, water was added, and liquid-liquid extraction was performed. After the organic layer was condensed under reduced pressure, the residue was refined by a silica gel column chromatography (mobile phase; heptane: toluene=20: 1), so that 1.20 g (yield: 85%) of the compound A-5 was obtained.

(4) Synthesis of Compound A-6

[0105] The following reagents and solvent were charged in a reaction vessel.

Iridium(III)·trihydrate: (850 mg, 2.40 mmol)

Compound A-5: 1.50 g (5.41 mmol)

Ethoxyethanol: 20 ml

Water: 10 ml

[0106] After stirred for 10 minutes at room temperature under a nitrogen stream, the reaction solution was heated to 90°C and was stirred for 6 hours. After the reaction solution was cooled to room temperature, a precipitate precipitated by addition of water was separated by filtration and was then washed with water. By vacuum drying of this solid at 100°C, 870 mg (47%) of the compound A-6 was obtained as a light yellow powder.

(5) Synthesis of Compound A-7

[0107] The following reagents and solvent were charged in a reaction vessel.

Compound A-6: 870 mg (1.16 mmol)
Acetylacetone: 0.21 ml (2.02 mmol)
Sodium carbonate: 800 mg (7.54 mmol)
Ethoxyethanol: 25 ml

[0108] After stirred for 20 minutes at room temperature under a nitrogen stream, the reaction solution was heated to 100°C and was stirred for 7 hours. After the reaction solution was cooled to room temperature, a precipitate precipitated by addition of water was separated by filtration and was then washed with water. By vacuum drying of this solid at 100°C, 640 mg (65%) of the compound A-7 was obtained as a yellow powder.

(6) Synthesis of Example Compound (2)

[0109] The following reagents and solvent were charged in a reaction vessel.

Compound A-7: 640 mg (0.76 mmol)

Compound A-5: 527 mg (1.90 mmol)

Glycerol: 15 ml

[0110] The reaction solution was heated to 190°C under a nitrogen stream and stirred for 6 hours. After the reaction solution was cooled to room temperature, a precipitate precipitated by addition of water was separated by filtration and was then washed with water. By vacuum drying of this solid at 100°C, 715 mg (93%) of the example compound (2) was obtained as a yellow powder.

[0111] By a mass spectrometry, 1,021 which was M+ of the example compound (2) was confirmed.

[0112] In addition, the structure of the example compound (2) was confirmed by ^{1}H-NMR measurement.

^{1}H-NMR ($CDCl_3$, 400 MHz) σ(ppm): 2.47 (s, 9H), 3.13 (s, 9H), 3.57 (s, 9H), 6.45 (s, 3H), 6.80 (d, J=5.0 Hz, 3H), 7.31 (d, J=5.0 Hz, 3H), 7.75 (s, 3H), 8.17 (s, 3H)

[0113] When the emission spectrum of the example compound (2) in a diluted toluene solution was measured, the emission maximum wavelength was 467 nm.

[0114] In this case, for the measurement of T_1, a phosphorescent component in a toluene solution (1×10^{-4} mol/L) was measured at an excitation wavelength of 350 nm, and the rising wavelength of the spectrum was shown. For this measurement, a spectrophotometer F-4500 manufactured by Hitachi Co., Ltd. was used.

[0115] In addition, as for the example compound (2), the quantum yield calculated from the absorbance and the emission area of the compound itself was 0.71. The absorbance was evaluated from the absorption spectrum of a toluene solution (1×10^{-4} mol/L) measured using an ultraviolet-visible spectrophotometer V-560 manufactured by JASCO Corporation.

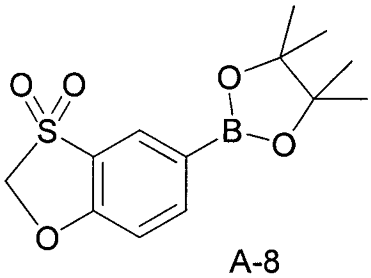
Example 2

Synthesis of Example Compound (10)

[0116] An example compound (10) was synthesized in a manner similar to that of Example 1 except that the compound A-3 was changed to the following compound A-8.

[0117]

[Chem. 9]



A-8

[0118] By the mass spectrometry, 973 which was M+ of the example compound (10) was confirmed.

[0119] In addition, the structure of the example compound (10) was confirmed by ^{1}H-NMR measurement.

^{1}H-NMR ($CDCl_3$, 400 MHz) σ(ppm): 2.48 (s, 9H), 6.45 (s, 3H), 6.83 (d, J=5.0 Hz, 3H), 7.27 (d, J=5.0 Hz, 3H), 7.70 (s, 3H), 7.89 (s, 3H)

[0120] In addition, when the emission spectrum of the example compound (10) in a diluted toluene solution was measured in a manner similar to that of Example 1, the emission maximum wavelength was 468 nm.

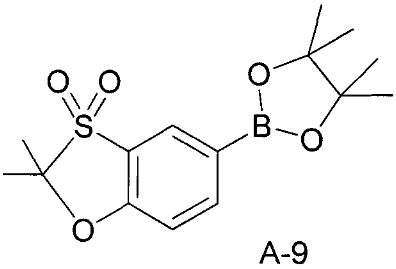
Example 3

Synthesis of Example Compound (18)

[0121] An example compound (18) was synthesized in a manner similar to that of Example 1 except that the compound A-3 was changed to the following compound A-9.

[0122]

[Chem. 10]



A-9

[0123] By the mass spectrometry, 1,057 which was M+ of the example compound (18) was confirmed.

[0124] In addition, when the emission spectrum of the example compound (18) in a diluted toluene solution was measured in a manner similar to that of Example 1, the emission maximum wavelength was 469 nm.

Example 4

[0125] In this example, an organic light emitting element having the structure in which an anode/hole transport layer/electron blocking layer/light emitting layer/hole blocking layer/electron transport layer/cathode were provided on a substrate in this order was formed by the following method.

[0126] An ITO film having a thickness of 120 nm was formed as an anode on the glass substrate by a sputtering method and was used as a transparent conductive support substrate (ITO substrate).

[0127] The following organic compound layers and electrode layers were sequentially formed on this ITO substrate by vacuum deposition using resistance heating in a vacuum chamber at a pressure of 10^{-5} Pa. In this case, the opposing electrode was formed to have an area of 3 mm^2.

Hole transport layer (40 nm): A-10

Electron blocking layer (10 nm): A-11

Light emitting layer (30 nm) host material 1: A-12, guest material: example compound (2) (10 percent by weight)

Hole blocking layer (10 nm): A-13

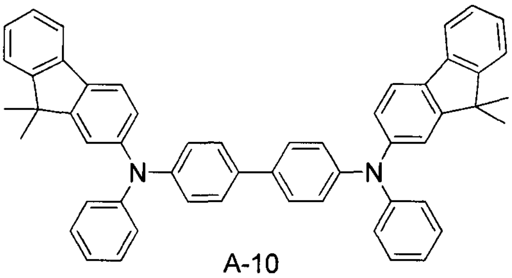
Electron transport layer (30 nm): A-14

Metal electrode layer 1 (0.5 nm): LiF

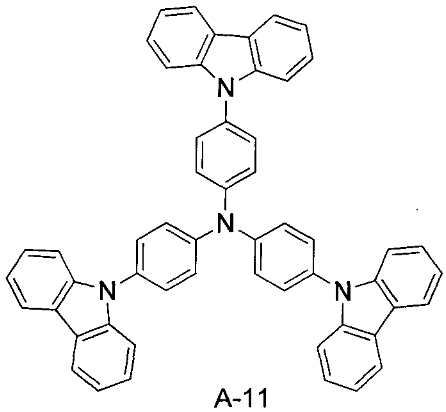
Metal electrode layer 2 (100 nm): aluminum

[0128]

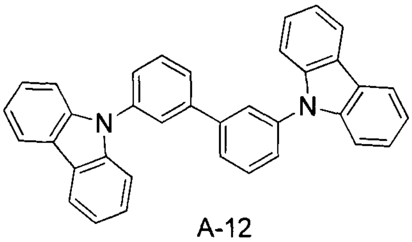
[Chem. 11]



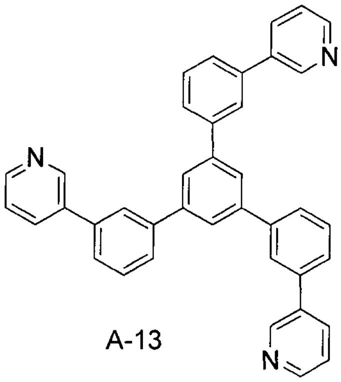
A-10



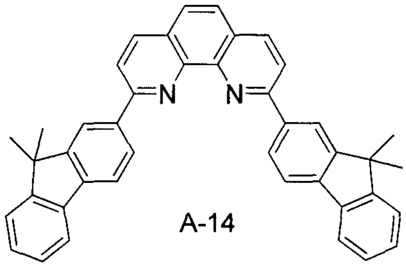
A-11



A-12



A-13



A-14

[0129] Next, in order to prevent element degradation of the organic light emitting element by absorption of water, a protective glass plate was placed in a dry air atmosphere to cover the organic light emitting element and was sealed with an acrylate resin adhesive. The organic light emitting element was obtained as described above.

[0130] In the organic light emitting element thus obtained, when the ITO electrode and the Al electrode were used as a positive electrode and a negative electrode, respectively, and an applied voltage was measured at a luminescent brightness of 500 cd/m^2, a voltage of 4.0 V was obtained. The luminescent efficiency was 12.2 lm/W, and blue light emission was observed.

Example 5

[0131] An organic light emitting element was formed in a manner similar to that of Example 4 except that the guest material was changed to the example compound (10).

[0132] In the organic light emitting element thus obtained, when the ITO electrode and the Al electrode were used as a positive electrode and a negative electrode, respectively, and an applied voltage was measured at a luminescent brightness of 500 cd/m^2, a voltage of 4.1 V was obtained. The luminescent efficiency was 12.0 lm/W, and blue light emission was observed.

[0133] As described above, the organometallic complex of the present invention emits light in a blue region and has a high luminescent efficiency. Therefore, when this organometallic complex is used for an organic light emitting element, an organic light emitting element having a high luminescent efficiency can be obtained.

[0134] While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all such modifications and equivalent structures and functions.

[0135] This application claims the benefit of Japanese Patent Application No. 2011-166968, filed July 29, 2011, which is hereby incorporated by reference herein in its entirety.

Reference Signs List

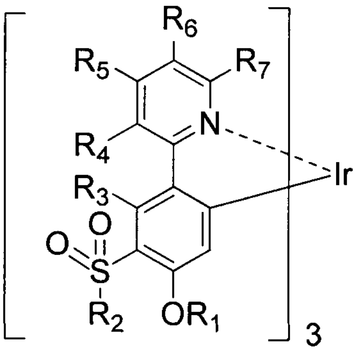
[0136]

8	TFT Element
11	Anode
12	Organic Compound Layer
13	Cathode

CLAIMS

[1] An organometallic complex represented by the following general formula [1]

[Chem. 1]



[1]

where in the general formula [1], R_1 to R_7 are each independently selected from a hydrogen atom and an alkyl group,

the alkyl group indicates an alkyl group having 1 to 4 carbon atoms,

a sulfone group and an ether group in the general formula [1] may bond to each other to form a five-membered ring or a six-membered ring.

[2] An organic light emitting element comprising:

a pair of electrodes; and

at least one organic compound layer arranged between the pair of electrodes,

wherein the organic compound layer includes the organometallic complex according to Claim 1.

[3] The organic light emitting element according to Claim 2,

wherein the at least one organic compound layer includes a light emitting layer,

the light emitting layer includes a host material and a guest material, and

the guest material includes the organometallic complex.

[4] A display device comprising:

a plurality of pixels,

wherein the pixels each include the organic light emitting element according to Claim 2 and a switching element connected thereto.

[5] An image output device comprising:

an input portion to input image information; and

a display portion to output an image,

wherein the display portion has a plurality of pixels, and

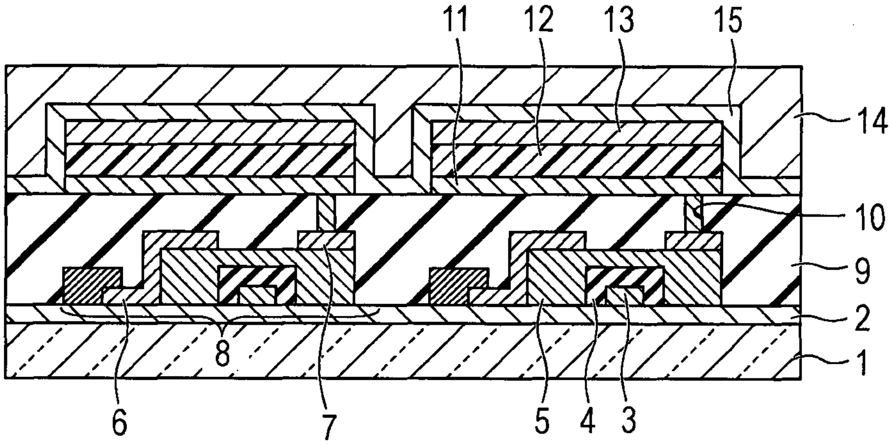
the pixels each include the organic light emitting element according to Claim 2 and a switching element connected thereto.

[6] A lighting device comprising:

the organic light emitting element according to Claim 2; and

an inverter circuit connected thereto.

FIGURE 1



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2012/068047

A. CLASSIFICATION OF SUBJECT MATTER

Int.Cl. C07F15/00(2006.01)i, C09K11/06(2006.01)i, H01L51/50(2006.01)i

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

Int.Cl. C07F15/00, C09K11/06, H01L51/50

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Published examined utility model applications of Japan 1922-1996
Published unexamined utility model applications of Japan 1971-2012
Registered utility model specifications of Japan 1996-2012
Published registered utility model applications of Japan 1994-2012

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

CAplus/REGISTRY(STN), JSTPlus(JDreamII)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	HISAMATSU, Y. et al, "Design and Synthesis of Light Emitting Devices Responding to the Exterior Environment Based on Regioselective Functionalization of Cyclometalated Iridium Complexes", Dai 9 Kai Jisedai wo Ninau Yuki Kagaku Symposium Koen Yoshi Shu, Nagoya, Japan: The Pharmaceutical Society of Japan, 2011.05.22, p.24-25 page 25, complex 10	1-6
P,X	WO 2012/066686 A1 (TOKYO UNIVERSITY OF SCIENCE EDUCATIONAL FOUNDATION ADMINISTRATIVE ORGANIZATION) 2012.05.24 abstract, paragraph [0034] (family: none)	1-6

☑ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* 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

Date of the actual completion of the international search 20.09.2012	Date of mailing of the international search report 02.10.2012
Name and mailing address of the ISA/JP **Japan Patent Office** 3-4-3, Kasumigaseki, Chiyoda-ku, Tokyo 100-8915, Japan	Authorized officer Takeshi SHIKAMI 4H 9547 Telephone No. +81-3-3581-1101 Ext. 3443

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	HISAMATSU, Y. et al, "Design and Synthesis of Blue-Emitting Cyclometalated Iridium(III) Complexes Based on Regioselective Functionalization", European Journal of Inorganic Chemistry, December 2011, Vol.2011, No.35, p.5360-5369 page 5360, complex 10	1-6
A	RAGNI, R. et al, "Iridium(III) Complexes with Sulfonyl and Fluorine Substituents: Synthesis, Stereochemistry and Effect of Functionalisation on their Photophysical Properties", Chemistry--A European Journal, 2009, Vol.15, No.1, p.136-148	1-6
A	ZHOU, G. et al, "Robust Tris-Cyclometalated Iridium(III) Phosphors with Ligands for Effective Charge Carrier Injection/Transport: Synthesis, Redox, Photophysical, and Electrophosphorescent Behavior", Chemistry--An Asian Journal, 2008, Vol.3, No.10, p.1830-1841	1-6
P,A	JP 2011-256116 A (UBE KOSAN KABUSHIKI KAISHA) 2011.12.22 claims, paragraphs [0115]-[0117] (family: none)	1-6
A	WO 2011/013685 A1 (TOKYO INSTITUTE OF TECHNOLOGY) 2011.02.03 abstract, claims (family: none)	1-6
A	JP 2009-46601 A (KONICA MINOLTA HOLDINGS, INC.) 2009.03.05 claims, paragraphs [0097]-[0100] (family: none)	1-6
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