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(54) **PHOTORESIST COMPOSITION, COMPOUND AND PROCESS OF PRODUCING PHOTORESIST PATTERN**

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(57) **ABSTRACT**

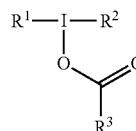
A photoresist composition comprising:
a resin having an acid-labile group,
an acid generator, and
a compound represented by formula (I):

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(I)

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wherein R¹, R² and R³ each independently represents a C1-C24 hydrocarbon group in which a hydrogen atom can be replaced by a substituent and in which a methylene group can be replaced by an oxygen atom, a sulfur atom or a carbonyl group.

**PHOTORESIST COMPOSITION, COMPOUND
AND PROCESS OF PRODUCING
PHOTORESIST PATTERN**

[0001] This nonprovisional application claims priority under 35 U.S.C. §119(a) on Patent Application No. 2014-040138 filed in JAPAN on Mar. 3, 2014, the entire contents of which are hereby incorporated by reference.

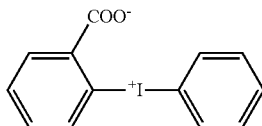
TECHNICAL FIELD

[0002] This disclosure relates to a photoresist composition, a compound and a process of producing photoresist pattern.

BACKGROUND ART

[0003] A photoresist composition is used for semiconductor microfabrication employing a lithography process.

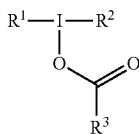
[0004] US2012/028188A1 discloses a photoresist composition which comprises a resin having an acid-labile group, an acid generator, 2,6-diisopropylaniline and the compound represented as follow.



SUMMARY OF THE DISCLOSURE

[0005] The present invention relates to the followings:

[1] A photoresist composition comprising:
a resin having an acid-labile group,
an acid generator, and
a compound represented by formula (I):



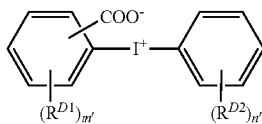
wherein R^1 , R^2 and R^3 each independently represents a C1-C24 hydrocarbon group in which a hydrogen atom can be replaced by a substituent and in which a methylene group can be replaced by an oxygen atom, a sulfur atom or a carbonyl group.

[2] The photoresist composition according to [1] wherein R^1 is a group represented by $R^4 - CO - O - *$ where $*$ represents a binding site to I, R^4 represents a C1-C22 hydrocarbon group in which a methylene group can be replaced by an oxygen atom or a carbonyl group and in which a hydrogen atom can be replaced by a hydroxyl group, a halogen atom or a nitro group.

[3] The photoresist composition according to [1] or [2] wherein R^2 is a C6-C24 aromatic hydrocarbon group in which a hydrogen atom can be replaced by a substituent.

[4] The photoresist composition according to any one of [1] to [3] which further comprises an onium carboxylic acid salt.

[5] The photoresist composition according to [4] in which the onium salt is a salt represented by formula (D):



in which R^{D1} and R^{D2} respectively represent a C1-C12 monovalent hydrocarbon group, a C1-C6 alkoxy group, a C2-C7 acyl group, a C2-C7 acyloxy group, a C2-C7 alkoxy-carbonyl group, a nitro group or a halogen atom, and the symbols m' and n' each independently represent an integer of 0 to 4.

[6] A compound represented by formula (IA):



in which R^{1A} is a group represented by $R^{4A} - CO - O - *$ where $*$ represents a binding site to I, R^{4A} represents a C1-C22 hydrocarbon group in which a methylene group has been replaced by an oxygen atom, a sulfur atom or a carbonyl group and in which a hydrogen atom can be replaced by a halogen atom or a hydroxyl group, or a C3-C22 alicyclic hydrocarbon group in which a hydrogen atom has been replaced by a halogen atom or a hydroxyl group;

R^{2A} is a phenyl group optionally substituted with a C1-C5 alkyl group; and

R^{3A} represents a C1-C22 hydrocarbon group in which a methylene group has been replaced by an oxygen atom, a sulfur atom or a carbonyl group and in which a hydrogen atom can be replaced by a halogen atom or a hydroxyl group, or a C3-C22 alicyclic hydrocarbon group in which a hydrogen atom has been replaced by a halogen atom or a hydroxyl group.

[7] A process for producing a photoresist pattern comprising the following steps (1) to (5):

[0006] (1) a step of applying the photoresist composition according any one of [1] to [5] on a substrate,

[0007] (2) a step of forming a composition film by conducting drying,

[0008] (3) a step of exposing the composition film to radiation,

[0009] (4) a step of baking the exposed composition film, and

[0010] (5) a step of developing the baked composition film.

DESCRIPTION OF PREFERRED
EMBODIMENTS

<Photoresist Composition>

[0011] The photoresist composition of the present invention comprises a resin having an acid-labile group, which resin is sometimes referred to as “Resin (A),”

an acid generator, which is sometimes referred to as “acid generator (B),” and

a compound represented by formula (I), which is sometimes referred to as “Compound (I)”.

<Compound represented by formula (I)>



[0012] In the formula, R^1 , R^2 and R^3 each independently represents a C1-C24 hydrocarbon group in which a hydrogen

atom can be replaced by a substituent and in which a methylene group can be replaced by an oxygen atom, a sulfur atom or a carbonyl group, preferably represents a C1-C24 hydrocarbon group in which a hydrogen atom can be replaced by a substituent and in which a methylene group can be replaced by an oxygen atom or a carbonyl group.

[0013] The hydrocarbon group represented by R^1 , R^2 and R^3 include an aliphatic hydrocarbon group, an alicyclic hydrocarbon group, an aromatic hydrocarbon group and combination of the groups selected therefrom. Examples of the aliphatic hydrocarbon group include an alkyl group such as a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a tert-butyl group, a pentyl group, a hexyl group, an octyl group and a nonyl group. The aliphatic hydrocarbon group has preferably 1 to 9 carbon atoms, more preferably 3 to 8 carbon atoms.

[0014] The alicyclic hydrocarbon group may be monocyclic or polycyclic. Examples thereof include a cycloalkyl group such as a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a cyclononyl group and a cyclododecyl group, and a polycyclic hydrocarbon group such as an adamantyl group, or a norbornyl group.

[0015] The alicyclic hydrocarbon group comprises preferably a cyclic structure which has 6 to 10 carbon atoms.

[0016] Examples of the aromatic hydrocarbon group include an aryl group such as phenyl group, 1-naphthyl group, 2-naphthyl group, an anthryl group, tolyl group, xylyl group, cumenyl group, mesityl group, biphenyl group, an anthryl group and phenanthryl group.

[0017] The aromatic hydrocarbon group has preferably 6 to 10 carbon atoms.

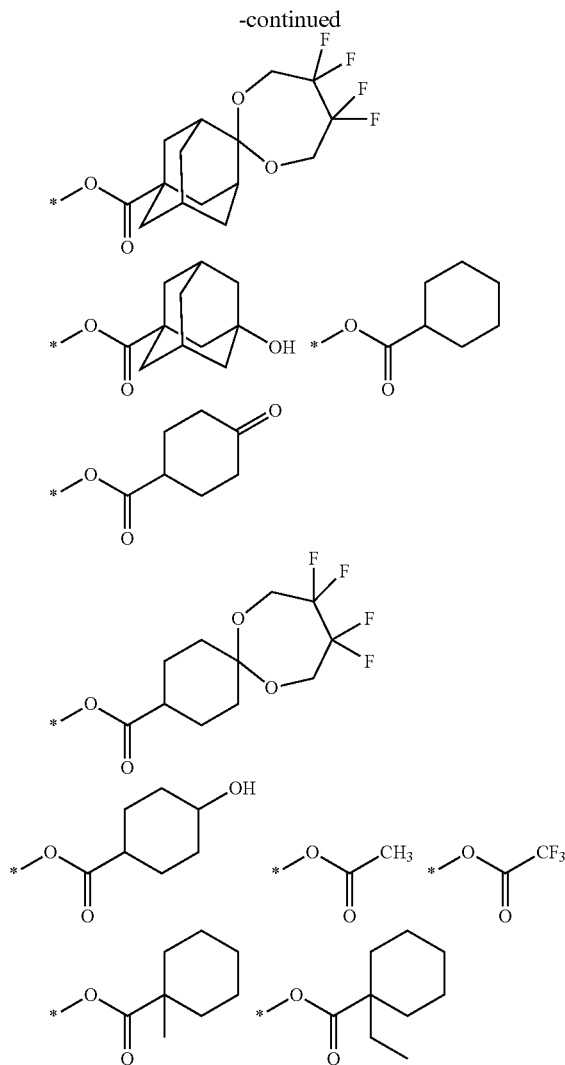
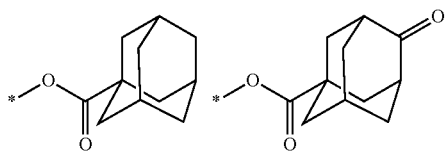
[0018] Examples of the combination as to the hydrocarbon group include an alkyl-cycloalkyl group; a cycloalkyl-alkyl group; an alkyl-aromatic hydrocarbon group such as 2-methylphenyl group, 3-methylphenyl group, 4-methylphenyl group, 4-ethylphenyl group, 4-propylphenyl group, 4-isopropylphenyl group, 4-butylphenyl group, 4-(t-butyl)phenyl group, 4-hexylphenyl group, 2,6-diethylphenyl group or 2-methyl-6-ethylphenyl; alicyclic hydrocarbon-alicyclic hydrocarbon such as adamantyl-cycloalkyl group or cycloalkyl-adamantyl group; an (alicyclic hydrocarbon)-aryl group an aralkyl group such as phenylmethyl group, a 1-phenylethyl group, a 2-phenylethyl group, a 1-phenyl-1-propyl group, a 1-phenyl-2-propyl group, a 2-phenyl-2-propyl group, a 3-phenyl-1-propyl group, 4-phenyl-1-butyl, a 5-phenyl-1-pentyl group or a 6-phenyl-1-hexyl group.

[0019] The substituent for the hydrocarbon group includes a hydroxy group, a nitro group and a halogen atom.

[0020] Examples of the halogen atom include a fluorine atom, a chlorine atom and a bromine atom.

[0021] The substituent is preferably a hydroxy group or a halogen atom, more preferably a hydroxy group or a fluorine atom.

[0022] In formula (1), examples of the moiety represented by R^3-CO-O^* , where * represents a binding site to 1, include the following ones.



[0023] R^3 is preferably a C3-C22 alicyclic hydrocarbon group in which a methylene group can be replaced by an oxygen atom or a carbonyl group and in which a hydrogen atom can be replaced by a hydroxy group or a halogen atom, more preferably a C3-C18 cycloalkyl group, an adamantyl group or combination of them. In the C3-C18 cycloalkyl group, the adamantyl group and the combination of them, a methylene group can be replaced by an oxygen atom or a carbonyl group, and a hydrogen atom can be replaced by a hydroxy group or a halogen atom.

[0024] The cycloalkyl group for R^3 has more preferably 3 to 12 carbon atoms.

[0025] R^1 is preferably a group represented by R^4-CO-O^* where * represents a binding site to 1, R^4 represents a C1-C22 hydrocarbon group in which a methylene group can be replaced by an oxygen atom or a carbonyl group, and in which a hydrogen atom can be replaced by a hydroxyl group, a halogen atom or a nitro group, preferably by a hydroxyl group or a halogen atom.

[0026] R^4 is preferably a C3-C22 alicyclic hydrocarbon group in which a methylene group can be replaced by an oxygen atom or a carbonyl group and in which a hydrogen

atom can be replaced by a hydroxy group or a halogen atom, more preferably a C3-C18 cycloalkyl group, an adamantyl group or combination of them, and still more preferably a cycloalkyl group, an adamantyl group or combination of them. In the C3-C18 cycloalkyl group, the adamantyl group and the combination of them, a methylene group can be replaced by an oxygen atom or a carbonyl group, and a hydrogen atom can be replaced by a hydroxy group or a halogen atom.

[0027] The cycloalkyl group for R^4 has more preferably 3 to 12 carbon atoms. R^4 is preferably the same group as R^3 . In formula (I), R^1 is preferably the same group as R^3 —CO—O—*.

[0028] R^2 is preferably a C6-C24 aromatic hydrocarbon group in which a hydrogen atom can be replaced by a substituent, more preferably a C6-C18 aromatic hydrocarbon group in which a hydrogen atom can be replaced by a substituent, and still more preferably a phenyl group.

[0029] For R^2 , examples of the substituent for the aromatic hydrocarbon group include a halogen atom and a C1-C12 hydrocarbon group in which a methylene group can be replaced by an oxygen atom or a carbonyl group, preferably include a halogen atom and a C1-C12 alkyl group in which a methylene group can be replaced by an oxygen atom or a carbonyl group. As to the substituent, examples of the hydrocarbon group in which a methylene group has been replaced by an oxygen atom or a carbonyl group include an alkoxy group, an acyl group, an acyloxy group, and an alkoxy-carbonyl group.

[0030] Examples of the alkoxy group include a methoxy group, an ethoxy group, an n-propoxy group, an isopropoxy group, an n-butoxy group, a sec-butoxy group, a tert-butoxy group, a pentyloxy group and a hexyloxy group, preferably a C1-C6 alkoxy group.

[0031] Examples of the acyl group include an acetyl group, a propanoyl group, a benzoyl group and a cyclohexanecarbonyl group, preferably a C2-C7 acyl group.

[0032] Examples of the acyloxy group include those having an oxy group [—O—] attached to the carbonyl group which any one of the above-mentioned specific acyl groups has, preferably a C2-C8 acyloxy group.

[0033] Examples of the alkoxy-carbonyl group include those having a carbonyl group [—CO—] attached to the oxygen atom which any one of the above-mentioned specific acyl groups has.

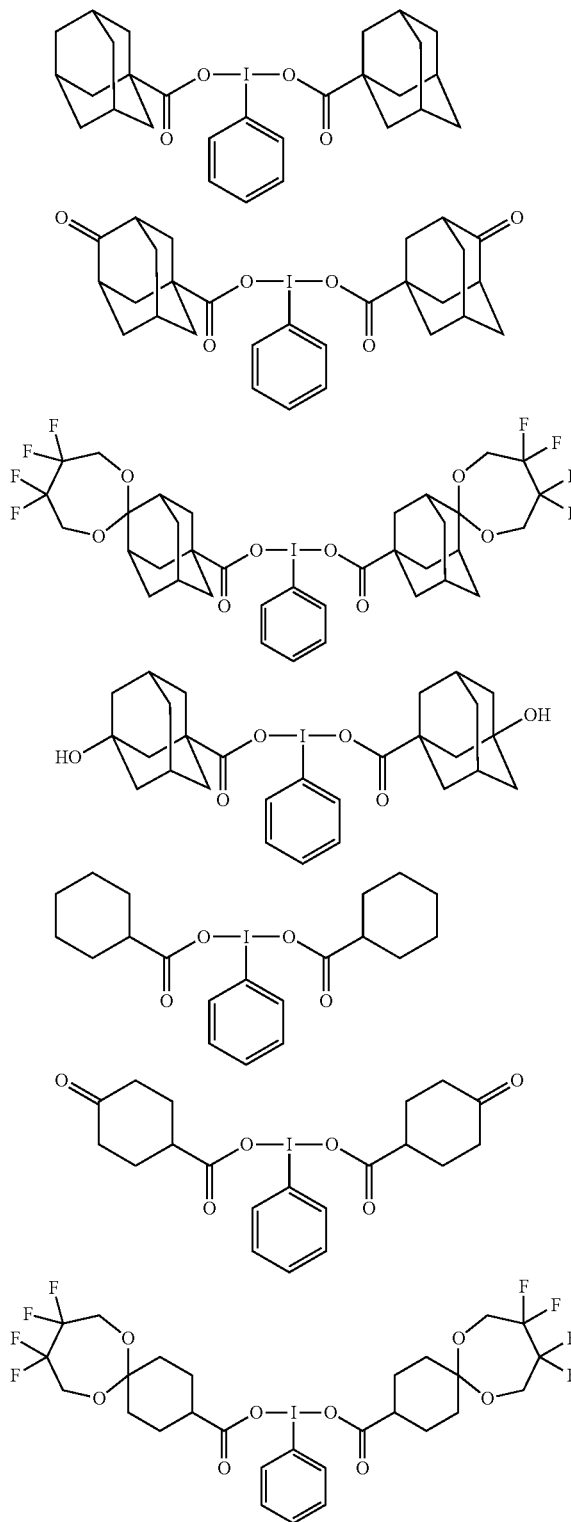
[0034] Examples of the halogen atom include a fluorine atom, a chlorine atom and a bromine atom.

[0035] Specific examples of Compound (I) include the compounds represented by formula (I) in which R^1 is a group represented by R^4 —CO—O—* where * represents a binding site to I, R^4 represents a C1-C4 alkyl group, R^9 is a phenyl group optionally substituted with a C1-C5 alkyl group, and R^3 represents a C1-C22 hydrocarbon group in which a methylene group can be replaced by an oxygen atom or a carbonyl group and in which a hydrogen atom can be replaced by a hydroxyl group or a halogen atom; and

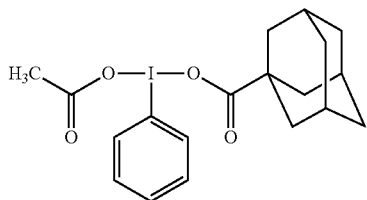
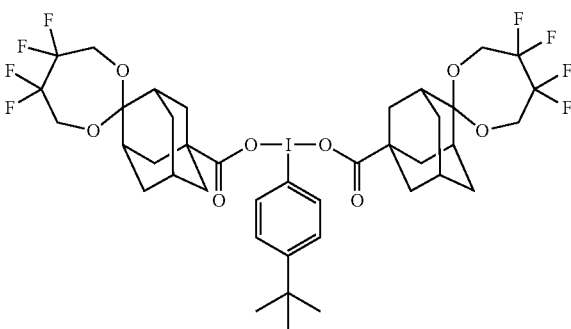
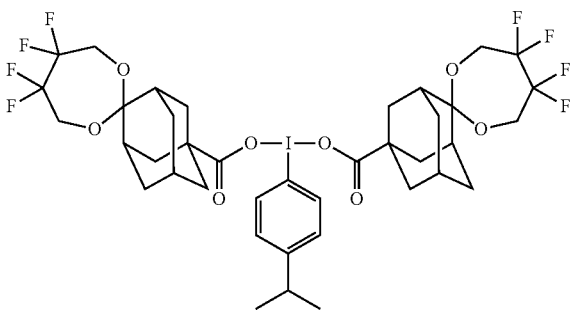
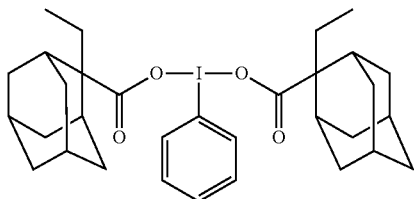
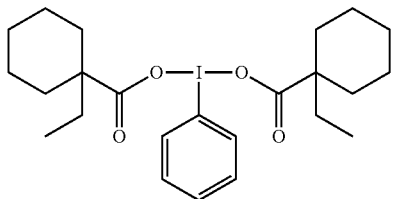
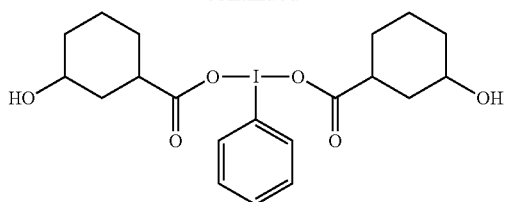
the compounds represented by formula (I) in which R^1 is a group represented by R^4 —CO—O—* where * is as defined above, R^4 represents a C1-C22 hydrocarbon group in which a methylene group can be replaced by an oxygen atom, a sulfur atom or a carbonyl group, preferably by an oxygen atom or a carbonyl group, and in which a hydrogen atom has been replaced by a hydroxyl group or a halogen atom, R^2 is a phenyl group optionally substituted with a C1-C5 alkyl group, and R^3 represents a C1-C22 hydrocarbon group in which a methylene group can be replaced by an oxygen atom, a sulfur atom or a carbonyl group, preferably by an oxygen

atom or a carbonyl group, and in which a hydrogen atom can be replaced preferably by a hydroxyl group or a halogen atom.

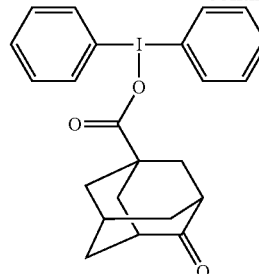
[0036] More specific examples of Compound (I) include the following ones.



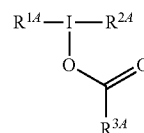
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[0037] Compound (I) is preferably one represented by formula (IA):



wherein in which R^{1A} is a group represented by $R^{4A}-CO-O-*$ where * represents a binding site to I, R^{4A} represents a C1-C22 hydrocarbon group in which a methylene group has been replaced by an oxygen atom, a sulfur atom or a carbonyl group and in which a hydrogen atom can be replaced by a halogen atom or a hydroxyl group, or a C3-C22 alicyclic hydrocarbon group in which a hydrogen atom has been replaced by a halogen atom or a hydroxyl group;

R^{2A} is a phenyl group optionally substituted with a C1-C5 alkyl group; and

R^{3A} represents a C1-C22 hydrocarbon group in which a methylene group has been replaced by an oxygen atom, a sulfur atom or a carbonyl group and in which a hydrogen atom can be replaced by a halogen atom or a hydroxyl group, or

a C3-C22 alicyclic hydrocarbon group in which a hydrogen atom has been replaced by a halogen atom or a hydroxyl group.

[0038] For R^{1A} and R^{3A} , examples of the hydrocarbon group include the same as mentioned about R^1 and R^3 .

[0039] Each of R^{1A} and R^{3A} has preferably a C3-C22 alicyclic hydrocarbon group in which two methylene group has been replaced respectively by an oxygen atom, in which two methylene groups have been replaced respectively by a sulfur atom, in which one methylene group has been replaced by a carbonyl group or in which a hydrogen atom has been replaced by a hydroxy group, more preferably a C3-C22 alicyclic hydrocarbon group in which two methylene groups have been replaced respectively by an oxygen atom, in which one methylene group has been replaced by a carbonyl group or in which a hydrogen atom has been replaced by a hydroxy group.

[0040] For R^1 and R^3 , the alicyclic hydrocarbon group is a polycyclic group such as an adamantyl group or combination of two C6-C8 cycloalkyl groups such as cyclohexane or cyclooctane ring.

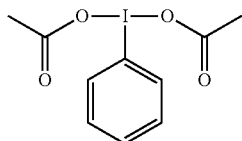
[0041] The photoresist composition which comprises the compound represented by formula (IA) can show a large focal margin [DOF] when a photoresist pattern is formed using the

composition. The compound represented by formula (IA) used for a photoresist composition is one aspect of this disclosure.

[0042] The content of Compound (I) is preferably 0.001% by mass or more, more preferably 0.005% by mass or more, still more preferably 0.01% by mass or more, based on sum of solid component. The content is also preferably 10% by mass or less, more preferably 8% by mass or less, still more preferably 5% by mass or less, based on the sum.

[0043] In this specification, “solid component” means components other than solvent in the photoresist composition.

[0044] Compound (I) is available on the market, which specifically includes the compound of formula (I) in which R¹ is CH₃—CO—O—*, R² is a phenyl group and R³ is a methyl group and which compound is represented by formula (I-1-a) and sometimes referred to as “Compound (I-1-a)”.



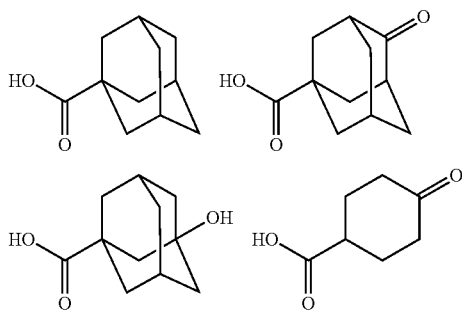
(I-1-a)

[0045] The compound of formula (I) in which R¹ and R³ are represented by R⁴—CO—O—*, where R⁴ is as defined above, can be prepared by reacting Compound (I-1-a) with the compounds of formula (I-c) for transesterification:

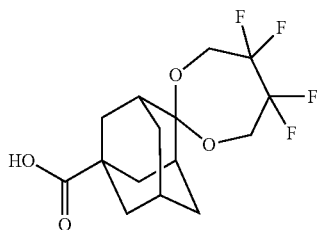


where R⁴ is as defined above.

[0046] Examples of the compound of formula (I-c) include the following ones.

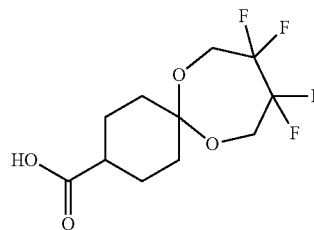


(I-c-A)



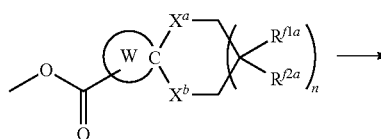
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(I-c-B)

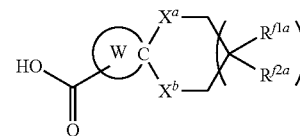


[0047] The reaction for transesterification can be conducted at temperature from 20° C. to 80° C., for 0.5 to 12 hour in an organic solvent such as an organic solvent including chloroform or monochlorobenzene.

[0048] The compounds of formulae (I-c-A,B), examples of which include those of formulae (I-c-A) and (I-c-B), can be prepared by reacting the compound of formula (I-d-A,B) with NaOH.



(I-d-A,B)



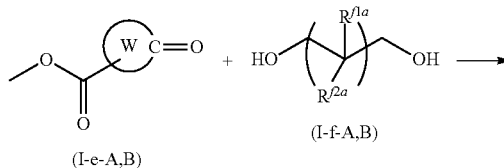
(I-c-A,B)

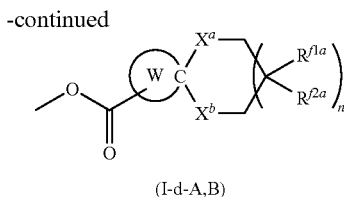
[0049] In each formula, the ring W represents a C1-C12 alicyclic hydrocarbon group in which a methylene group can be replaced by an oxygen atom or a carbonyl group and in which a hydrogen atom can be replaced by a hydroxy group or a halogen atom, X^a and X^b each independently represent an oxygen atom or a sulfur atom, R^{1a} and R^{2a} each independently represent a halogen atom, and n represents an integer of 1 to 3.

[0050] Examples of the alicyclic hydrocarbon group represented by the ring W include those as mentioned above regarding R⁴. Examples of the halogen atom include a fluorine atom, a chlorine atom and a bromine atom.

[0051] The reaction of the compound of formulae (I-c-A, B) can be conducted, for example, at temperature from 0° C. to 120° C. in an organic solvent such as acetone or dichloroethane. The amount of NaOH is preferably from 1.0 to 2.0 mol per 1 mol of the compound.

[0052] The compounds of formula (I-d-A,B) can be prepared by reacting the compound of formula (I-e-A,B) with the compounds of formula (I-f-A, B).

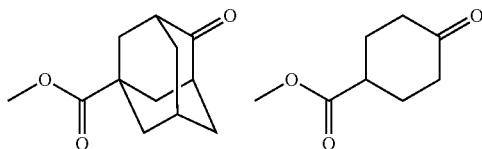




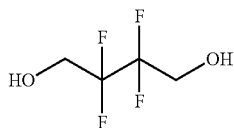
[0053] (In the formulae, the ring W, X^a, X^b, R^{1a}, R^{2a} and n are as defined above.)

[0054] The reaction can be conducted, for example, at temperature from 40° C. to 150° C., for 0.5 to 12 hours in an organic solvent such as acetone or dichloroethane.

[0055] Examples of the compound of formula (I-e-A, B) include the following ones.



[0056] Examples of the compound of formula (I-f-A, B) include the following ones.



<Resin (A)>

[0057] The resin having an acid-labile group, which is Resin (A), usually comprises a structural unit having an acid-labile group. Hereinafter, the structural unit is sometimes referred to as “structural unit (a1)”.

[0058] Preferably Resin (A) further comprises another structural unit than the structural unit (a1), i.e. a structural unit having no acid-labile group, which is sometimes referred to as “structural unit (s)”.

[0059] The structural unit (a1) is derived from a compound having an acid-labile group which compound is sometimes referred to as “Monomer (a1)”.

[0060] Herein, “an acid-labile group” means a group which has a hydrophilic group, such as a hydroxy group or a carboxy group, resulting from removing a leaving group therefrom by the action of an acid.

[0061] For Resin (A), the acid-labile groups represented by formulae (1) and (2) are preferred:



[0062] In formula (1), R^{a1}, R^{a2} and R^{a3} independently each represent a C1-C8 alkyl group, a C3-C20 alicyclic hydrocarbon group or a group consisting of them, and R^{a1} and R^{a2} can

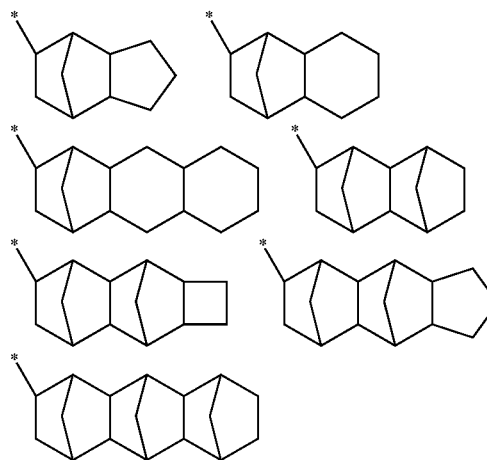
be bonded each other to form a C2-C20 divalent hydrocarbon group, n_a represents an integer of or 1, and * represents a binding site.



[0063] In formula (2), R^{a1'} and R^{a2'} independently each represent a hydrogen atom or a C1-C12 hydrocarbon group, and R^{a3'} represents a C1-C20 hydrocarbon group, and R^{a2'} and R^{a3'} can be bonded each other to form a C2-C20 divalent hydrocarbon group, and one or more —CH₂— in the hydrocarbon group and the divalent hydrocarbon group can be replaced by —O— or —S—, X represents an oxygen atom or a sulfur atom, and * represents a binding site.

[0064] For R^{a1}, R^{a2} and R^{a3}, specific examples of the alkyl group include a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group and an octyl group.

[0065] The alicyclic hydrocarbon group may be monocyclic or polycyclic. Examples of the alicyclic hydrocarbon group include a monocyclic alicyclic hydrocarbon group such as a C3-C20 cycloalkyl group (e.g. a cyclopentyl group, a cyclohexyl group, a cycloheptyl group and a cyclooctyl group) and a polycyclic alicyclic hydrocarbon group such as a decahydronaphthyl group, an adamantyl group, a norbornyl group, and the followings:



in which * represents a binding site.

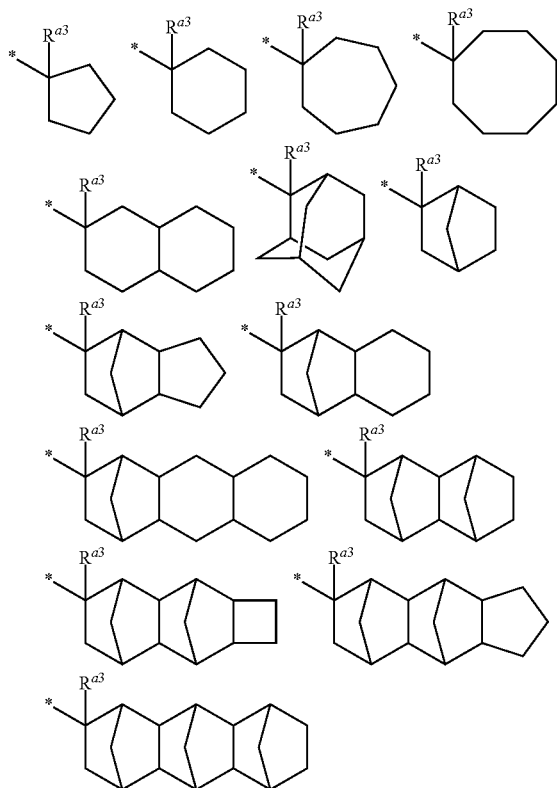
[0066] The alicyclic hydrocarbon group preferably has 3 to 16 carbon atoms.

[0067] Examples of the group consisting of alkyl and alicyclic hydrocarbon group include a methylcyclohexyl group, a dimethylcyclohexyl group, a methylnorbornyl group, an adamantylmethyl group, and a norbornylethyl group.

[0068] The “n_a” is preferably 0.

[0069] When the divalent hydrocarbon group is formed by bonding R^{a1} and R^{a2} each other, examples of the moiety

—C(R^{a1})(R^{a2})(R^{a3}) include the following groups and the divalent hydrocarbon group preferably has 3 to 16 carbon atoms.



wherein R^{a3} is the same as defined above and * represents a binding site.

[0070] The group represented by formula (1) wherein R^{a1}, R^{a2} and R^{a3} independently each represent a C1-C8 alkyl group such as a tert-butyl group, the group represented by formula (1) wherein R^{a1} and R^{a2} are bonded each other to form an adamantyl ring and R^{a3} is a C1-C8 alkyl group such as a 2-alkyl-2-adamantyl group, and the group represented by formula (1) wherein R^{a1} and R^{a2} are C1-C8 alkyl groups and R^{a3} is an adamantyl group such as a 1-(1-adamantyl)-1-alkylalkoxycarbonyl group are preferred.

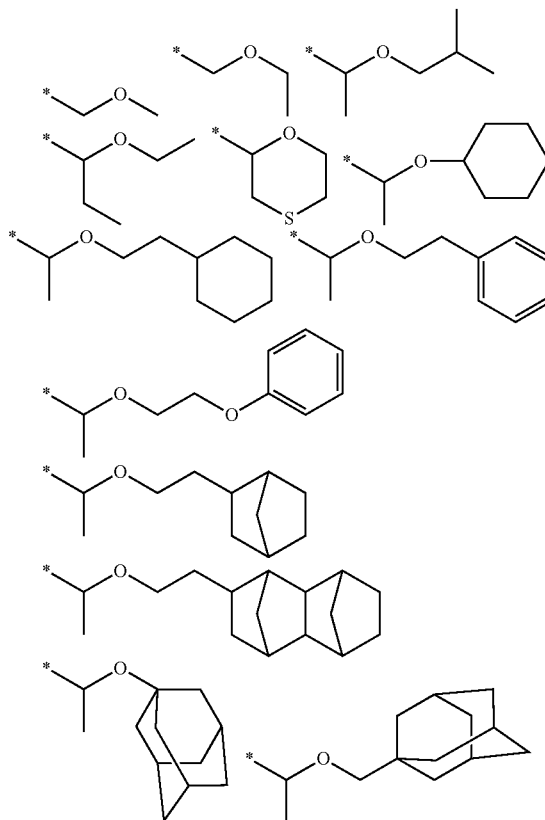
[0071] For formula (2), examples of the hydrocarbon group include an alkyl group, an alicyclic hydrocarbon group, an aromatic hydrocarbon group and a group consisting of two or more of them.

[0072] Examples of the aliphatic hydrocarbon group and the alicyclic hydrocarbon group include the same as described above. Examples of the aromatic hydrocarbon group include an aryl group such as a phenyl group, a naphthyl group, a p-methylphenyl group, a p-tert-butylphenyl group, a p-adamantylphenyl group, a tolyl group, a xylyl group, a cumyl group, a mesityl group, a biphenyl group, an anthryl group, a phenanthryl group, a 2,6-diethylphenyl group and a 2-methyl-6-ethylphenyl group.

[0073] Examples of the divalent hydrocarbon group formed by bonding R^{a2'} and R^{a3'} each other include those formed by removing a hydrogen atom from the hydrocarbon group represented by R^{a1'}, R^{a2'} and R^{a3'}.

[0074] At least one of R^{a1'} and R^{a2'} is preferably a hydrogen atom.

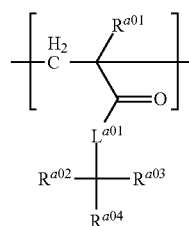
[0075] Examples of the group represented by formula (2) include the following.



[0076] Monomer (a1) is preferably a monomer having an acid-labile group in its side chain and an ethylenic unsaturated group, more preferably a (meth)acrylate monomer having an acid-labile group in its side chain, and still more preferably a (meth)acrylate monomer having the group represented by formula (1) or (2).

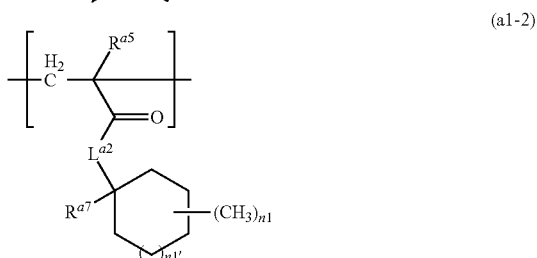
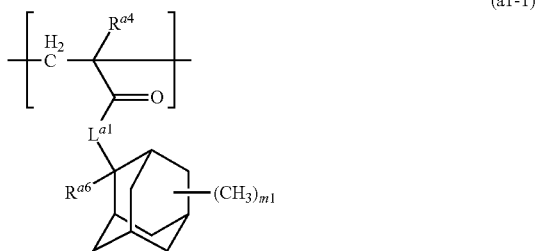
[0077] The (meth)acrylate monomer having an acid-labile group in its side chain is preferably those which comprise a C5-C20 alicyclic hydrocarbon group. The resin which comprises a structural unit derived from such monomers can provide improved resolution for a photoresist pattern to be prepared therefrom.

[0078] The structural unit derived from a (meth)acrylate monomer having the group represented by formula (1) is preferably one of structural units represented by formulae (a1-0), (a1-1) and (a1-2).



(a1-0)

-continued



In each formula, $L^{\alpha O1}$, $L^{\alpha 1}$ and $L^{\alpha 2}$ each independently represent $-\text{O}-$ or $^*\text{O}-(\text{CH}_2)_{k1}-\text{CO}-\text{O}-$ in which $k1$ represents an integer of 1 to 7 and * represents a binding site to $-\text{CO}-$,

$R^{\alpha O1}$, $R^{\alpha 4}$ and $R^{\alpha 5}$ each independently represent a hydrogen atom or a methyl group,

$R^{\alpha O2}$, $R^{\alpha O3}$, $R^{\alpha O4}$, $R^{\alpha 6}$ and $R^{\alpha 7}$ each independently represent a C1-C8 alkyl group, a C3-C18 alicyclic hydrocarbon group, or a group formed by combining them,

$m1$ represents an integer of 0 to 14,

$n1$ represents an integer of 0 to 10, and

$n1'$ represents an integer of 0 to 3.

[0079] Hereinafter, the structural units represented by formulae (a1-0), (a1-1) and (a1-2) are respectively referred to as "structural unit (a1-0)", "structural unit (a1-1)" and "structural unit (a1-2)". Resin (A) may comprise two or more of such structural units.

[0080] $L^{\alpha O1}$ is preferably $^*\text{O}-$ or $^*\text{O}-(\text{CH}_2)_{f1}-\text{CO}-\text{O}-$ in which * represents a binding site to $-\text{CO}-$, and $f1$ represents an integer of 1 to 4, and is more preferably $^*\text{O}-$ or $^*\text{O}-\text{CH}_2-\text{CO}-\text{O}-$, and is especially preferably $^*\text{O}-$.

[0081] $R^{\alpha O1}$ is preferably a methyl group.

[0082] For $R^{\alpha O2}$, $R^{\alpha O3}$ and $R^{\alpha O4}$, examples of the alkyl group, the alicyclic hydrocarbon group and the group formed by combining them include the same as referred for $R^{\alpha 1}$, $R^{\alpha 2}$ and $R^{\alpha 3}$.

[0083] The alkyl group preferably has 1 to 6 carbon atoms.

[0084] The alicyclic hydrocarbon group preferably has 3 to 8 carbon atoms and more preferably 3 to 6 carbon atoms. The alicyclic hydrocarbon group is preferably a saturated aliphatic cyclic hydrocarbon group. The group formed by combining them preferably has 18 carbon atoms or less in total, examples of which include a methylcyclohexyl group, a dimethylcyclohexyl group, and a methylbornyl group. Each of $R^{\alpha O2}$ and $R^{\alpha O3}$ is preferably a C1-C6 alkyl group, more preferably a methyl group and an ethyl group.

[0085] $R^{\alpha O4}$ is preferably a C1-C6 alkyl group and a C5-C12 alicyclic hydrocarbon group, more preferably a methyl group, an ethyl group, a cyclohexyl group, and an adamantyl group.

[0086] Each of $L^{\alpha 1}$ and $L^{\alpha 2}$ is preferably $^*\text{O}-$ or $^*\text{O}-(\text{CH}_2)_{f1}-\text{CO}-\text{O}-$ in which * represents a binding site to $-\text{CO}-$, and $f1$ is the same as defined above, and is

more preferably $^*\text{O}-$ or $^*\text{O}-\text{CH}_2-\text{CO}-\text{O}-$, and is especially preferably $^*\text{O}-$.

[0087] Each of $R^{\alpha 4}$ and $R^{\alpha 5}$ is preferably a methyl group.

[0088] For $R^{\alpha 6}$ and $R^{\alpha 7}$, examples of the alkyl group include a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, a tert-butyl group, a pentyl group, a heptyl group, a 2-ethylheptyl group and an octyl group.

[0089] For $R^{\alpha 6}$ and $R^{\alpha 7}$, examples of the alicyclic hydrocarbon group include a monocyclic alicyclic hydrocarbon group such as a cyclohexyl group, a methylcyclohexyl group, a dimethylcyclohexyl group, a cycloheptyl group and a methylcycloheptyl group, and a polycyclic alicyclic hydrocarbon group such as a decahydronaphthyl group, an adamantyl group, a norbornyl group, a methylbornyl group and the following. For $R^{\alpha 6}$ and $R^{\alpha 7}$, examples of the group consisting of an alkyl group and an alicyclic hydrocarbon group include an aralkyl group such as a benzyl group, and a phenethyl group.

[0090] The alkyl group represented by $R^{\alpha 6}$ and $R^{\alpha 7}$ is preferably a C1-C6 alkyl group.

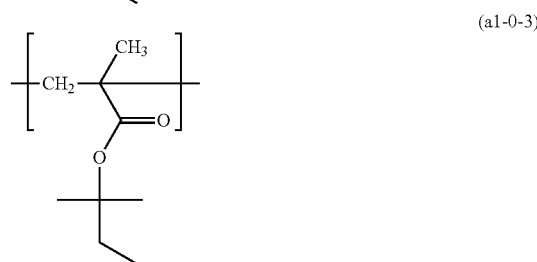
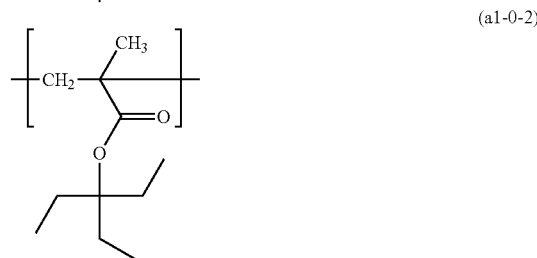
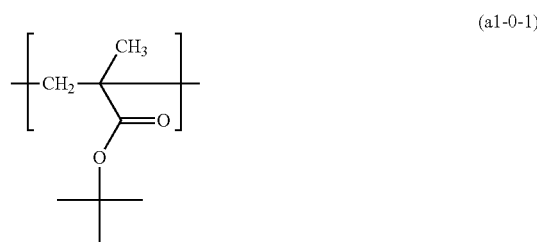
[0091] The alicyclic hydrocarbon group represented by $R^{\alpha 6}$ and $R^{\alpha 7}$ is preferably a C3-C8 alicyclic hydrocarbon group, more preferably a C3-C6 alicyclic hydrocarbon group.

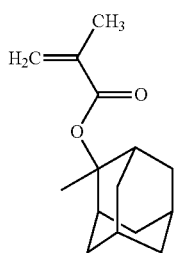
[0092] The "m1" is preferably an integer of 0 to 3, and is more preferably 0 or 1.

[0093] The "n1" is preferably an integer of 0 to 3, and is more preferably 0 or 1.

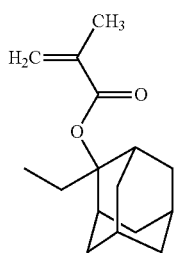
[0094] The "n1'" is preferably 0 or 1.

[0095] Examples of the structural unit (a1-0) include those represented by formulae (a1-0-1) to (a1-0-12), preferably those represented by formulae (a1-0-1) to (a1-0-10).

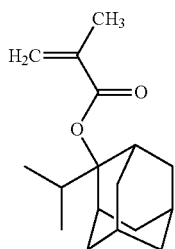




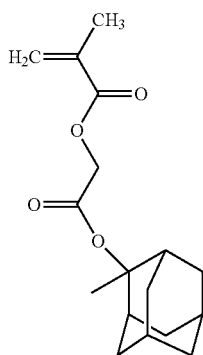
(a1-1-1)



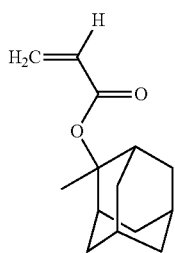
(a1-1-2)



(a1-1-3)

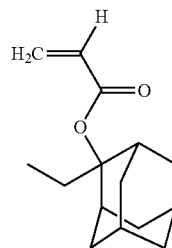


(a1-1-4)

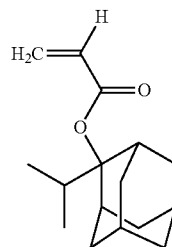


(a1-1-5)

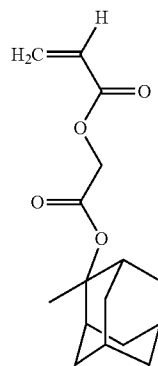
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(a1-1-6)

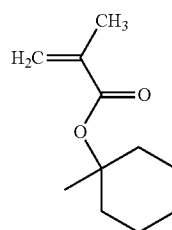


(a1-1-7)



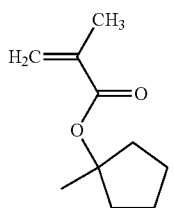
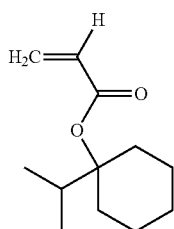
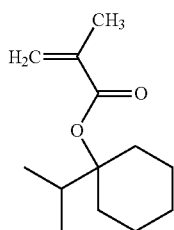
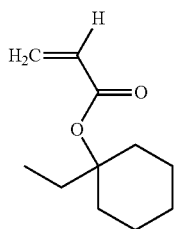
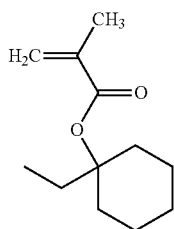
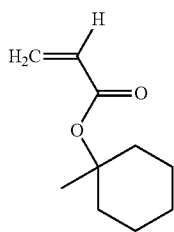
(a1-1-8)

[0098] Examples of the monomer from which the structural unit (a1-2) is derived include 1-ethylcyclopentan-1-yl acrylate, 1-ethylcyclopentan-1-yl methacrylate, 1-ethylcyclohexan-1-yl acrylate, 1-ethylcyclohexan-1-yl methacrylate, 1-ethylcycloheptan-1-yl acrylate, 1-ethylcycloheptan-1-yl methacrylate, 1-methylcyclopentan-1-yl acrylate, 1-methylcyclopentan-1-yl methacrylate, 1-isopropylcyclopentan-1-yl acrylate and 1-isopropylcyclopentan-1-yl methacrylate, preferably the monomers represented by formulae (a1-2-1) to (a1-2-12), more preferably the monomers represented by formulae (a1-2-3), (a1-2-4), (a1-2-9) and (a1-2-10), still more preferably the monomers represented by formulae (a1-2-3) and (a1-2-9).

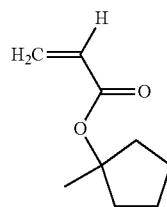


(a1-2-1)

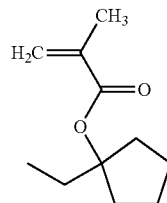
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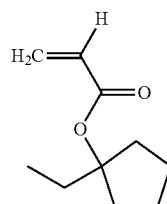
(a1-2-2)



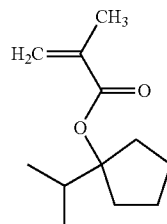
(a1-2-3)



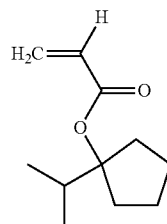
(a1-2-4)



(a1-2-5)



(a1-2-6)

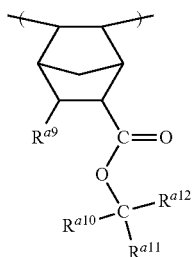


(a1-2-7)

[0099] The content of the structural unit having an acid-labile group in the resin is usually 10 to 95% by mole, preferably 15 to 90% by mole and more preferably 20 to 85% by mole based on 100% by mole of all the structural units of the resin. The content of the structural unit having an acid-labile group in the resin can be adjusted by adjusting the amount of the monomer having an acid-labile group based on the total amount of the monomers used for producing the resin.

[0100] When the resin comprises one or more of the structural units represented by formulae (a1-0), (a1-1) and (a1-2), the total content of the structural units is usually 10 to 95% by mole, preferably 15 to 90% by mole and more preferably 20 to 85% by mole based on 100% by mole of all the structural units of the resin.

[0101] Other examples of the structural unit (a1) having a group represented by formula (1) include a structural unit represented by formula (a1-3):



wherein R^{a9} represents a hydrogen atom, a carboxyl group, a cyano group, a C1-C3 aliphatic hydrocarbon group which can have a hydroxy group, or a group represented by $-\text{COOR}^{a13}$ group in which R^{a13} represents a C1-C8 alkyl group or a C3-C20 alicyclic hydrocarbon group, and a group composed of a C1-C8 aliphatic hydrocarbon group and a C3-C20 alicyclic hydrocarbon group, and the aliphatic hydrocarbon group and the alicyclic hydrocarbon group can have a hydroxy group, and a methylene in the alkyl group and the alicyclic hydrocarbon group can be replaced by $-\text{O}-$ or $-\text{CO}-$,

R^{a10} , R^{a11} and R^{a12} each independently represent a C1-C12 alkyl group or a C3-C20 alicyclic hydrocarbon group, and R^{a10} and R^{a11} can be bonded each other to form a C3-C20 ring together with the carbon atom to which R^{a10} and R^{a11} are bonded, and the alkyl group and the alicyclic hydrocarbon group can have a hydroxy group, and a methylene group in alkyl group and the alicyclic hydrocarbon group can be replaced by $-\text{O}-$ or $-\text{CO}-$.

[0102] As R^{a9} , examples of the alkyl group which can have a hydroxy group include a methyl group, an ethyl group, a propyl group, a hydroxymethyl group and a 2-hydroxyethyl group.

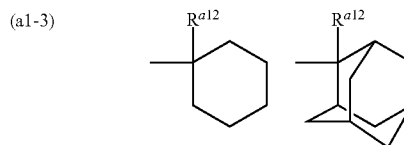
[0103] Examples of the aliphatic hydrocarbon group represented by R^{a13} include a methyl group, an ethyl group, a propyl group.

[0104] Examples of the alicyclic hydrocarbon group represented by R^{a13} include a cyclopropyl group, a cyclobutyl group, an adamantyl group, an adamantylmethyl group, a 1-adamantyl-1-methylethyl group, a 2-oxo-oxolan-3-yl group and a 2-oxo-oxolan-4-yl group.

[0105] Examples of the alkyl group represented by R^{a10} , R^{a11} and R^{a12} include a methyl group, an ethyl group, n-propyl group, an isopropyl group, n-butyl group, sec-butyl group, tert-butyl group, a pentyl group, a hexyl group, a heptyl group, a 2-ethylhexyl group, an octyl group.

[0106] The alicyclic hydrocarbon group represented by R^{a10} , R^{a11} and R^{a12} , which may be a monocyclic or polycyclic group. Examples of the monocyclic alicyclic hydrocarbon group include cycloalkyl groups such as a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a cycloheptyl group, a cyclodecyl group. Examples of the polycyclic alicyclic hydrocarbon group include a hydronaphthyl group, an adamantyl group, a 2-alkyladamantane-2-yl group, a 1-(adamantane-1-yl)alkane-1-yl group, a norbornyl group, a methylnorbornyl group, and an isobornyl group.

[0107] When the divalent hydrocarbon group is formed by bonding R^{a10} and R^{a11} , examples of $-\text{C}(\text{R}^{a10})(\text{R}^{a11})(\text{R}^{a12})$ include the following ones;



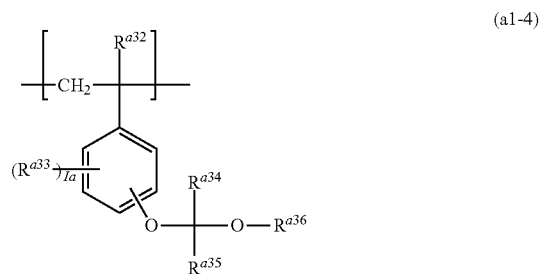
where R^{a12} is as defined above.

[0108] Examples of the monomer from which the structural unit represented by formula (a1-3) is derived include tert-butyl 5-norbornene-2-carboxylate, 1-cyclohexyl-1-methylethyl 5-norbornene-2-carboxylate, 1-methylcyclohexyl 5-norbornene-2-carboxylate, 2-methyl-2-adamantyl 5-norbornene-2-carboxylate, 2-ethyl-2-adamantyl 5-norbornene-2-carboxylate, 1-(4-methylcyclohexyl)-1-methylethyl 5-norbornene-2-carboxylate, 1-(4-hydroxycyclohexyl)-1-methylethyl 5-norbornene-2-carboxylate, 1-methyl-1-(4-oxocyclohexyl)ethyl 5-norbornene-2-carboxylate and 1-(1-adamantyl)-1-methylethyl 5-norbornene-2-carboxylate.

[0109] When the resin has a structural unit represented by formula (a1-3), the photoresist composition having excellent resolution and higher dry-etching resistance tends to be obtained.

[0110] When Resin (A) comprises the structural unit represented by formula (a1-3), the content of the structural unit is usually 10 to 95% by mole and preferably 15 to 90% by mole and more preferably 20 to 85% by mole based on total molar of all the structural units of the resin.

[0111] Other examples of the structural unit (a1) having a group represented by formula (2) include one represented by formula (a1-4):



wherein R^{a32} represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group or a C1-C6 halogenated alkyl group,

R^{a33} is independently in each occurrence a halogen atom, a hydroxy group, a C1-C6 alkyl group, a C1-C6 alkoxy group, a C2-C4 acyl group, a C2-C4 acyloxy group, an acryloyl group or a methacryloyl group, l^a represents an integer of 0 to 4,

R^{a34} and R^{a35} each independently represent a hydrogen atom or a C1-C12 hydrocarbon group, R^{a36} represents a C1-C20 aliphatic hydrocarbon group in which a methylene group can be replaced by $-\text{O}-$ or $-\text{S}-$, and R^{a35} and R^{a36} are bonded to each other to jointly represent a C2-C20 divalent hydrocarbon group in which a methylene group can be replaced by $-\text{O}-$ or $-\text{S}-$.

[0112] Examples of the alkyl group represented by R^{a32} and R^{a33} include a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, and a hexyl group,

preferably a C1-C4 alkyl group, more preferably a methyl group and an ethyl group, and still more preferably a methyl group.

[0113] Examples of the halogen atom represented by R^{a32} and R^{a35} include a fluorine atom, a chlorine atom and a bromine atom.

[0114] Examples of the alkoxy group represented by R^{a33} include a methoxy group, an ethoxy group, a propoxy group, an isopropoxy group, a butoxy group, an isobutoxy group, a sec-butoxy group, a tert-butoxy group, a pentyloxy group and a hexyloxy group. Examples of the acyl group represented by R^{a33} include an acetyl group, a propionyl group and a butyryl group, and examples of the acyloxy group represented by R^{a33} include an acetyloxy group, a propionyloxy group and a butyryloxy group.

[0115] Examples of halogen atom represented by R^{a32} and R^{a33} include a fluorine atom, a chlorine atom, and a bromine atom.

[0116] Examples of the groups represented by R^{a34} and R^{a35} include those as referred to for $R^{a1'}$ and $R^{a2'}$.

[0117] Examples of the groups represented by R^{a36} include those as referred to for $R^{a3'}$.

[0118] R^{a32} preferably represents a hydrogen atom.

[0119] R^{a33} is preferably a C1-C4 alkoxy group, more preferably a methoxy group and an ethoxy group, and still more preferably a methoxy group.

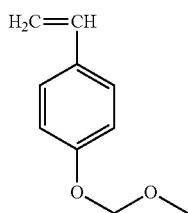
[0120] The symbol "a" preferably represents 0 or 1, more preferably 1.

[0121] R^{a34} preferably represents a hydrogen atom.

[0122] R^{a35} is preferably a C1-C12 monovalent hydrocarbon group, more preferably a methyl group and an ethyl group.

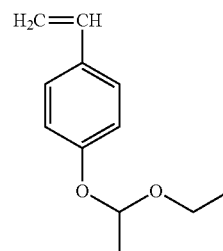
[0123] The hydrocarbon group represented by R^{a36} includes a C1-C18 alkyl group, a C3-C18 monovalent alicyclic hydrocarbon group, a C6-C18 monovalent aromatic hydrocarbon group, and any combination of them, and preferably a C1-C18 alkyl group, a C3-C18 monovalent alicyclic hydrocarbon group and a C7-C18 aralkyl group. These groups may be unsubstituted or substituted. The alkyl group and the monovalent alicyclic hydrocarbon group are preferably unsubstituted. As the substituent for the monovalent aromatic hydrocarbon group, a C6-C10 aryloxy group is preferred.

[0124] Examples of the monomer from which the structural unit (a1-4) is derived include monomers recited in JP2010-204646A1. Among them, the monomers represented by formulae (a1-4-1), (a1-4-2), (a1-4-3), (a1-4-4), (a1-4-5), (a1-4-6) and (a1-4-7) are preferred, and the monomers represented by formulae (a1-4-1), (a1-4-2), (a1-4-3), (a1-4-4) and (a1-4-5) are more preferred.

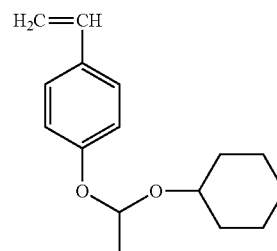


(a1-4-1)

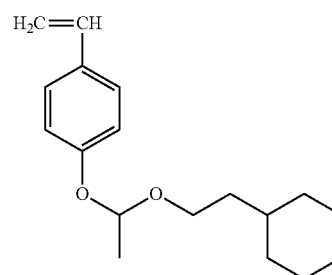
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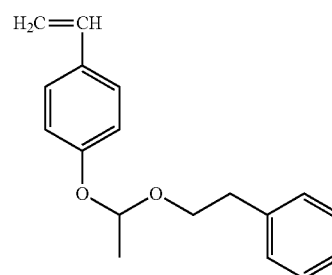
(a1-4-2)



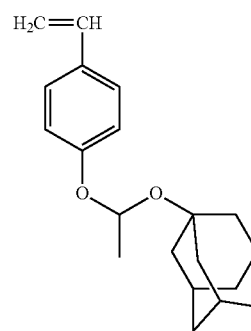
(a1-4-3)



(a1-4-4)

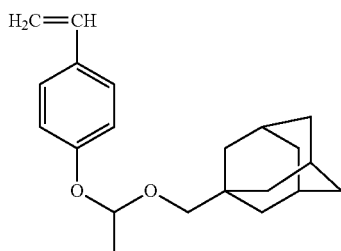


(a1-4-5)



(a1-4-6)

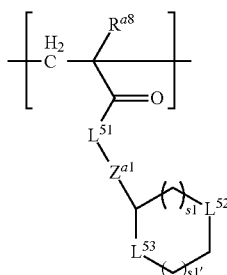
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(a1-4-7)

[0125] When Resin (A) comprises a structural unit represented by formula (a1-4), its content is usually 10 to 95% by mole, preferably 15 to 90% by mole and more preferably 20 to 85% by mole based on 100% by mole of all the structural units of the resin.

[0126] Other examples of the structural unit having an acid-labile group include one represented by formula (a1-5):



(a1-5)

[0127] In formula (1-5), R^{a8} represents a hydrogen atom, a halogen atom, or a C1-C6 alkyl group which may have a halogen atom,

Z^{a1} represents a single bond or $*(CH_2)_{k1}-CO-L^{54}$, in which $k1$ represents an integer of 1 to 4 and $*$ represents a binding site to L^{54} ,

L^{51} , L^{52} , L^{53} and L^{54} each independently represent an oxygen atom or a sulfur atom,

$s1$ represents an integer of 1 to 3, and $s1'$ represents an integer of 0 to 3.

[0128] Herein, the structural unit represented by formula (a1-5) is sometimes referred to as "structural unit (a1-5)".

[0129] Examples of halogen atoms include a fluorine atom and chlorine atom, preferably a fluorine atom.

[0130] Examples of the alkyl group which may have a halogen atom include a methyl group, an ethyl group, n-propyl group, an isopropyl group, n-butyl group, sec-butyl group, tert-butyl group, a pentyl group, a hexyl group, a heptyl group, a 2-ethylhexyl group, an octyl group, a fluoromethyl group, and a trifluoromethyl group.

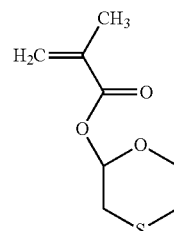
[0131] In the formula (a1-5), R^{a8} preferably represents a hydrogen atom, a methyl group, or trifluoromethyl group.

[0132] L^{51} represents preferably an oxygen atom.

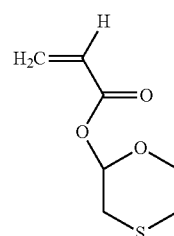
[0133] It is preferred that one of L^{52} and L^{53} represents an oxygen atom, while the other represents a sulfur atom.

[0134] $s1$ preferably represents 1. $s1'$ represents an integer of 0 to 2. Z^{a1} preferably represents a single bond or $*-CH_2-CO-O-$ wherein $*$ represents a binding site to L^{51} .

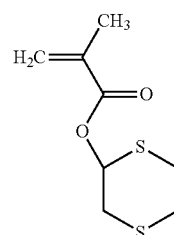
[0135] Examples of the monomer from which the structural unit (a1-5) is derived include one mentioned in JP2010-61117A1 and the following ones:



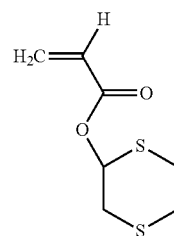
(a1-5-1)



(a1-5-2)



(a1-5-3)



(a1-5-4)

[0136] When Resin (A) comprises a structural unit (a1-5), its content is usually 1 to 50% by mole, preferably 3 to 45% by mole and more preferably 5 to 40% by mole based on 100% by mole of all the structural units of the resin.

[0137] Resin (A) comprises preferably one or more of the structural units (a1-0), (a1-1), (a1-2) and (a1-5), more preferably at least one of the structural units (a1-1), (a1-2) and (a1-5), still more preferably two or more of the structural units (a1-1), (a1-2) and (a1-5). Resin (A) comprises preferably the structural unit (a1-1). Specifically, Resin (A) comprises preferably the structural units (a1-1) and (a1-0), the structural units (a1-2) and (a1-0), the structural units (a1-5) and (a1-0), the structural units (a1-1) and (a1-2), the structural units (a1-1) and (a1-5), the structural units (a1-0), (a1-1) and (a1-2), or the structural units (a1-0), (a1-1) and (a1-5), and more preferably the structural units (a1-1) and (a1-2) or the structural units (a1-1) and (a1-5).

[0138] The structural unit (s) is derived from a monomer having no acid-labile group.

[0139] As to the monomer having no acid-labile group, monomers which have been known to in the art can be used as such monomer, and they are not limited to any specific one provided that it has no acid-labile group.

[0140] The structural unit having no acid-labile group preferably has a hydroxy group or a lactone ring. When the resin comprises the structural unit derived from the monomer having no acid-labile group and having a hydroxy group or a lactone ring, a photoresist composition capable of providing a photoresist film with good resolution and adhesiveness of photoresist to a substrate can be obtained.

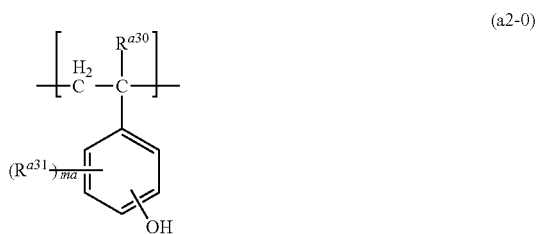
[0141] Hereinafter, the structural unit having no acid-labile group and having a hydroxy group is referred to as "structural unit (a2)", and the structural unit having no acid-labile group and having a lactone ring is referred to as "structural unit (a3)".

[0142] The hydroxy group which the structural unit (a2) has may be an alcoholic hydroxy group or a phenolic hydroxy group.

[0143] When KrF excimer laser (wavelength: 248 nm) lithography system, or a high energy laser such as electron beam and extreme ultraviolet is used as an exposure system, the resin which comprises the structural unit (a2) having a phenolic hydroxy group is preferred. When ArF excimer laser (wavelength: 193 nm) is used as an exposure system, the resin which comprises the structural unit (a2) having an alcoholic hydroxy group is preferred and the resin which comprises the structural unit (a2-1) described later is more preferred.

[0144] Resin (A) may comprise one or more of the structural units (a2).

[0145] Examples of the structural unit (a2) having a phenolic hydroxy group include one represented by formula (a2-0):



[0146] In formula (a2-0), R^{a30} represents a hydrogen atom, a halogen atom, a C1-C6 alkyl group or a C1-C6 halogenated alkyl group, R^{a31} is independently in each occurrence a halogen atom, a hydroxy group, a C1-C6 alkyl group, a C1-C6 alkoxy group, a C2-C4 acyl group, a C2-C4 acyloxy group, an acryloyl group or a methacryloyl group, m represents an integer of 0 to 4.

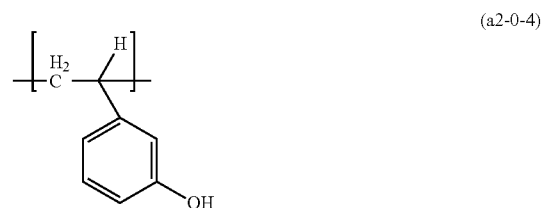
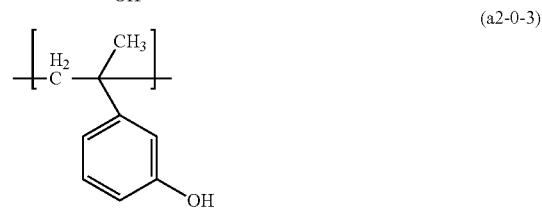
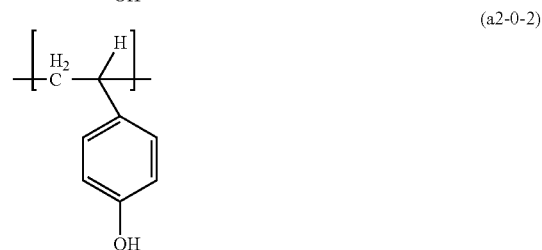
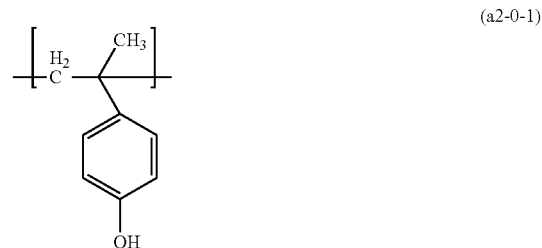
[0147] In the formula (a2-0), examples of the halogen atom include a fluorine atom, a chlorine atom, a bromine atom or iodine atom, examples of the C1-C6 alkyl group include a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group and a hexyl group, and a C1-C4 alkyl group is preferred and a C1-C2 alkyl group is more preferred and a methyl group is especially preferred.

[0148] Examples of the C1-C6 halogenated alkyl group include a trifluoromethyl group, a pentafluoroethyl group, a heptafluoropropyl group, a heptafluoroisopropyl group, a nonafluorobutyl group, a nonafluoro-sec-butyl group, a non-

affluoro-tert-butyl group, a perfluoropentyl group and a perfluorohexyl group. Examples of the C1-C6 alkoxy group include a methoxy group, an ethoxy group, a propoxy group, an isopropoxy group, a butoxy group, an isobutoxy group, a sec-butoxy group, a tert-butoxy group, a pentyloxy group and a hexyloxy group, and a C1-C4 alkoxy group is preferred and a C1-C2 alkoxy group is more preferred and a methoxy group is especially preferred. Examples of the C2-C4 acyl group include an acetyl group, a propionyl group and a butyryl group, and examples of the C2-C4 acyloxy group include an acetyloxy group, a propionyloxy group and a butyryloxy group.

[0149] In the formula (a2-0), m is preferably 0, 1 or 2, and is more preferably 0 or 1, and especially preferably 0.

[0150] Among them, the structural units represented by formulae (a2-0-2), (a2-0-3) and (a2-0-4) are preferred as the structural unit (a2-0), and those represented by formulae (a2-0-1) and (a2-0-2) are more preferred.

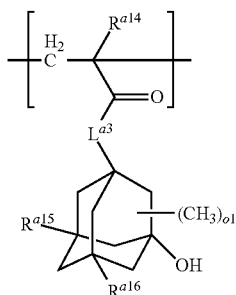


[0151] Resin (A) which comprises a structural unit represented by formula (a2-0) can be produced, for example, by polymerizing a monomer where its phenolic hydroxy group has been protected with a suitable protecting group, followed by deprotection. Examples of the protecting group for a phenolic hydroxy group include an acetyl group.

[0152] When Resin (A) comprises the structural unit represented by formula (a2-0), its content is usually 5 to 95% by

mole and preferably 10 to 80% by mole and more preferably 15 to 80% by mole based on total molar of all the structural units of the resin.

[0153] Examples of the structural unit (a2) having an alcoholic hydroxy group include one represented by formula (a2-1):



(a2-1)

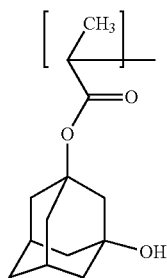
wherein R^{a14} represents a hydrogen atom or a methyl group, R^{a15} and R^{a16} each independently represent a hydrogen atom, a methyl group or a hydroxy group, L^{a3} represents $^*O-$ or $^*O-(CH_2)_{k2}-CO-O-$ in which * represents a binding site to $-CO-$, and $k2$ represents an integer of 1 to 7, and $o1$ represents an integer of 0 to 10.

[0154] Hereinafter, the structural unit represented by formula (a2-1) is referred to as "structural unit (a2-1)".

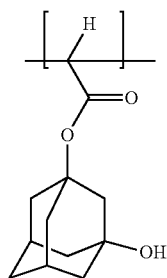
[0155] In the formula (a2-1), R^{a14} is preferably a methyl group. R^{a15} is preferably a hydrogen atom. R^{a16} is preferably a hydrogen atom or a hydroxy group. L^{a3} is preferably $^*O-$ or $^*O-(CH_2)_{f2}-CO-O-$ in which * represents a binding site to $-CO-$, and $f2$ represents an integer of 1 to 4, is more preferably $^*O-$ and $^*O-CH_2-CO-O-$, and is still more preferably $^*O-$, and $o1$ is preferably 0, 1, 2 or 3 and is more preferably 0 or 1.

[0156] Examples of monomers from which the structural unit (a2-1) is derived include compounds mentioned in JP2010-204646A.

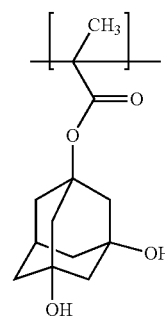
[0157] Preferred examples of the structural unit (a2-1) include those represented by formulae (a2-1-1) to (a2-1-6).



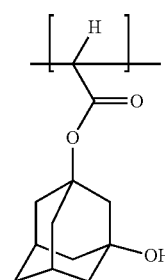
(a2-1-1)



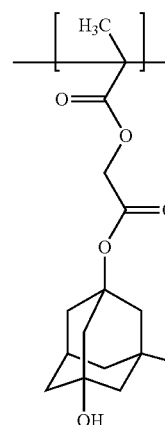
(a2-1-2)



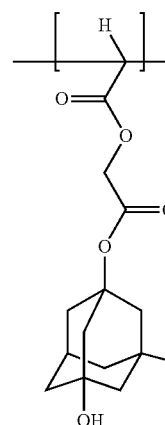
(a2-1-3)



(a2-1-4)



(a2-1-5)



(a2-1-6)

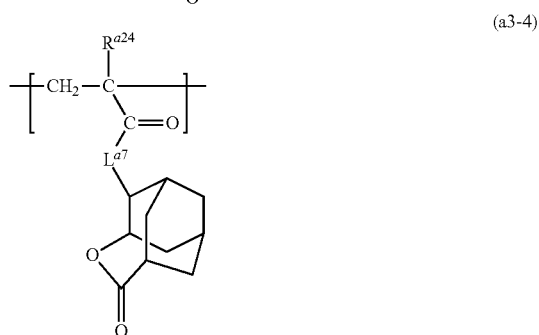
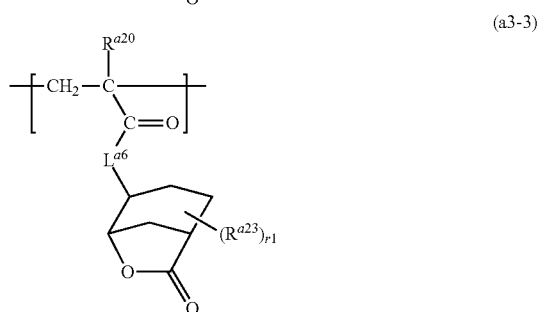
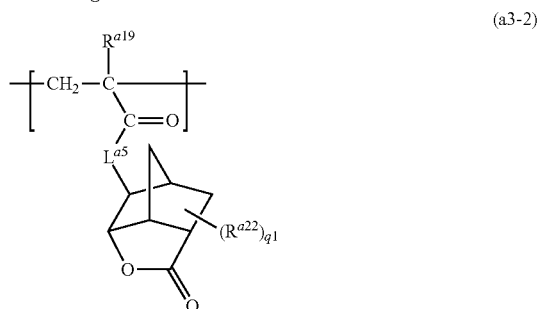
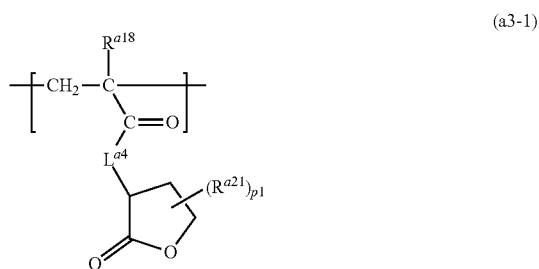
[0158] Among them, more preferred are the structural units represented by formulae (a2-1-1), (a2-1-2), (a2-1-3) and (a2-1-4), still more preferred are the structural units represented by formulae (a2-1-1) and (a2-1-3).

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[0159] When Resin (A) comprises the structural unit (a2-1), its content is usually 1 to 45% by mole, preferably 1 to 40% by mole, and more preferably 1 to 35% by mole, and especially preferably 2 to 20% by mole, based on total molar of all the structural units of the resin.

[0160] Examples of the lactone ring of the structural unit (a3) include a monocyclic lactone ring such as β -propiolactone ring, γ -butyrolactone ring and γ -valerolactone ring, and a condensed ring formed from a monocyclic lactone ring and the other ring. Among them, preferred are γ -butyrolactone ring and a condensed lactone ring formed from γ -butyrolactone ring and the other ring.

[0161] Preferred examples of the structural unit (a3) include those represented by formulae (a3-1), (a3-2), (a3-3) and (a3-4):



[0162] In formulae, L^{a4} , L^{a5} and L^{a6} each independently represent $*-O-$ or $*-O-(CH_2)_{k3}-CO-O-$ in which $*$ represents a binding site to $-CO-$ and $k3$ represents an integer of 1 to 7,

R^{a18} , R^{a19} and R^{a20} each independently represent a hydrogen atom or a methyl group,

R^{a21} represents a C1-C4 monovalent aliphatic hydrocarbon group, R^{a22} and R^{a23} are independently in each occurrence a carboxyl group, a cyano group or a C1-C4 monovalent aliphatic hydrocarbon group, R^{a24} each independently represent a hydrogen atom, a halogen atom, or a C1-C6 alkyl group which may have a halogen atom,

L^{a7} represents a single bond, $*^1-L^{a8}-O-$, $*^1-L^{a8}-CO-O-$, $*^1-L^{a8}-CO-O-L^{a9}-CO-O-$ or $*^1-L^{a8}-CO-O-L^{a9}-O-$ in which L^{a8} and L^{a9} each independently represent C1-C6 divalent alkanediyl group, $*^1$ represents a binding site to $-O-$,

and $p1$ represents an integer of 0 to 5, $q1$ and $r1$ independently each represent an integer of 0 to 3.

[0163] Examples of halogen atom represented by R^{a24} include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

[0164] Examples of the alkyl group represented by R^{a24} include a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, and a hexyl group, preferably a C1-C4 alkyl group, and more preferably a methyl group and an ethyl group.

[0165] As to R^{a24} , examples of the alkyl group which has an halogen atom include a trifluoromethyl group, a pentafluoroethyl group, a heptafluoropropyl group, a heptafluoroisopropyl group, a nonafluorobutyl group, a nonafluoro-sec-butyl group, a nonafluoro-tert-butyl group, a perfluoropentyl group, a perfluorohexyl group, a trichloromethyl group, a tribromomethyl group, and a triiodomethyl group.

[0166] As to L^{a8} and L^{a9} , examples of the alkanediyl group include a methylene group, an ethylene group, a propane-1,3-diyl group, a butane-1,4-diyl group, a pentane-1,5-diyl group and a hexane-1,6-diyl group, a butane-1,3-diyl group, 2-methylpropane-1,3-diyl group, a 2-methylpropane-1,2-diyl group, a pentane-1,4-diyl group and a 2-methylbutane-1,4-diyl group.

[0167] It is preferred that L^{a4} , L and L^{a6} each independently represent $*-O-$ or $*-O-(CH_2)_{d1}-CO-O-$ in which $*$ represents a binding site to $-CO-$ and $d1$ represents an integer of 1 to 4, and it is more preferred that L^{a4} , L^{a5} and L^{a6} are $*-O-$ and $*-O-CH_2-CO-O-$, and it is still more preferred that L^{a4} , L^{a5} and L^{a6} are $*-O-$.

[0168] R^{a10} , R^{a19} and R^{a20} are preferably methyl groups. R^{a21} is preferably a methyl group. It is preferred that R^{a22} and R^{a23} are independently in each occurrence a carboxyl group, a cyano group or a methyl group.

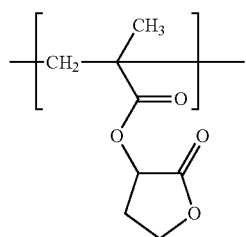
[0169] It is preferred that $p1$, $q1$ and $r1$ each independently represent an integer of 0 to 2, and it is more preferred that $p1$, $q1$ and $r1$ each independently represent 0 or 1.

[0170] R^{a24} is preferably a hydrogen atom or a C1-C4 alkyl group, more preferably a hydrogen atom, a methyl group or an ethyl group, and still more preferably a hydrogen atom or a methyl group.

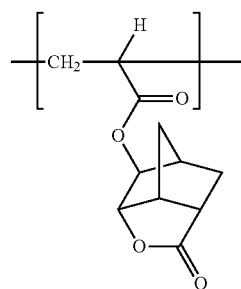
[0171] L^{a2} represents preferably a single bond or $*^1-L^{a8}-CO-O-$, more preferably a single bond, $*^1-CH_2-CO-O-$ or $*^1-C_2H_4-CO-O-$.

[0172] Examples of the structural unit (a3) include the following ones.

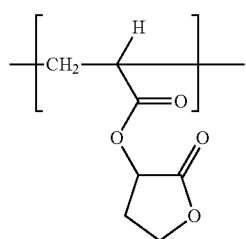
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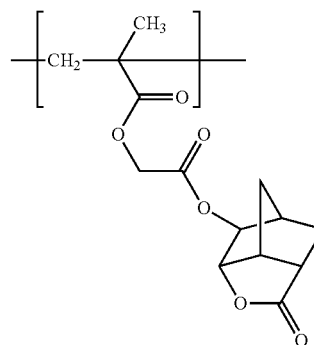
(a3-1-1)



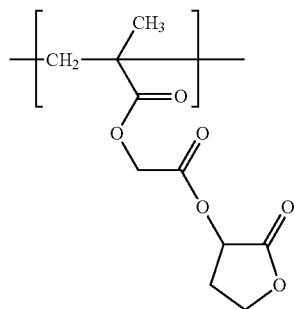
(a3-2-2)



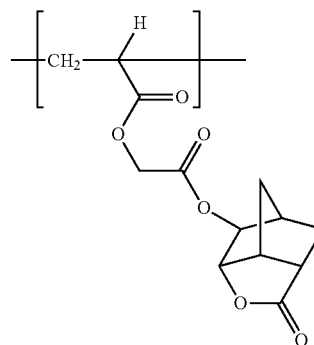
(a3-1-2)



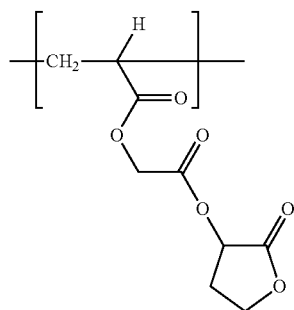
(a3-2-3)



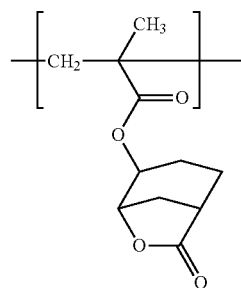
(a3-1-3)



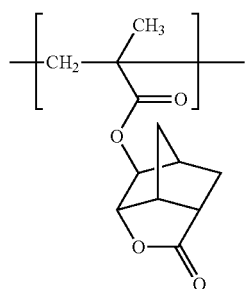
(a3-2-4)



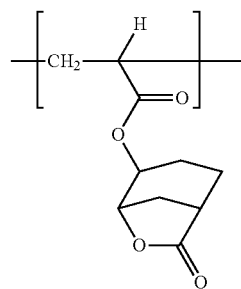
(a3-1-4)



(a3-3-1)

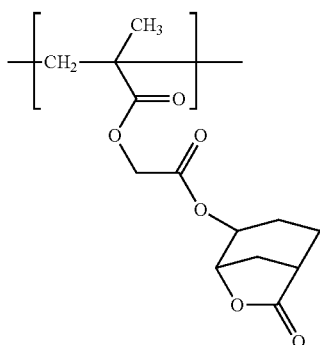


(a3-2-1)

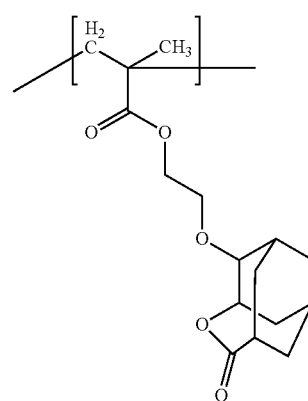


(a3-3-2)

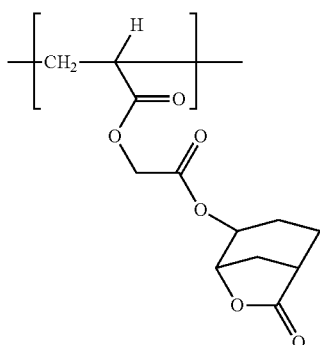
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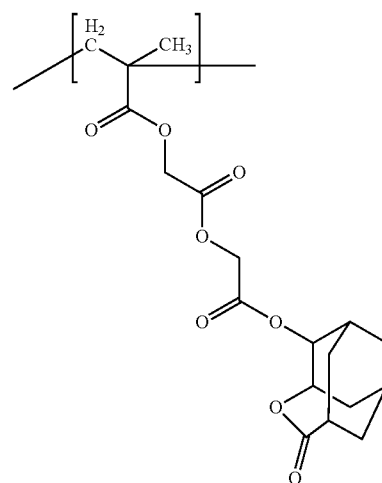
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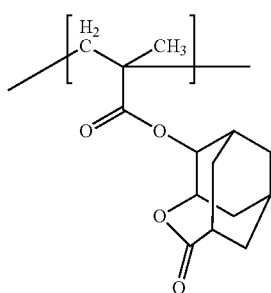
(a3-4-3)



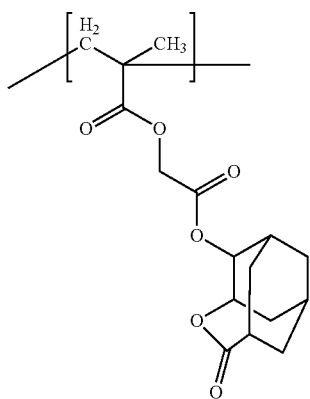
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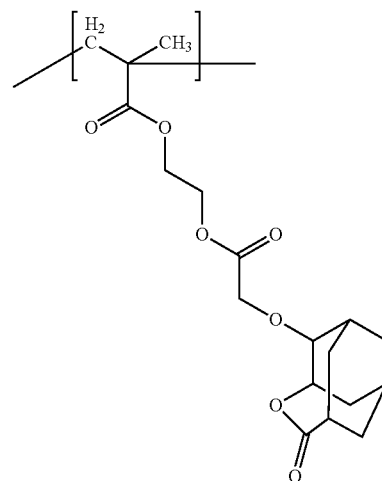
(a3-4-5)



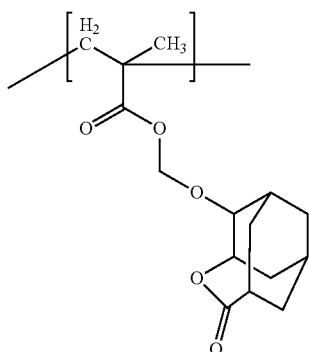
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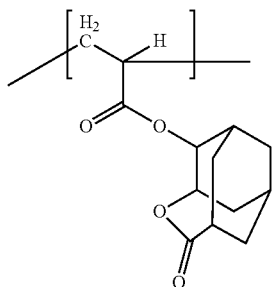
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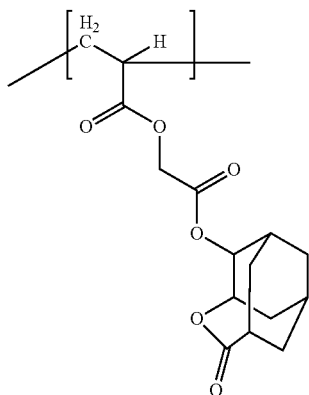
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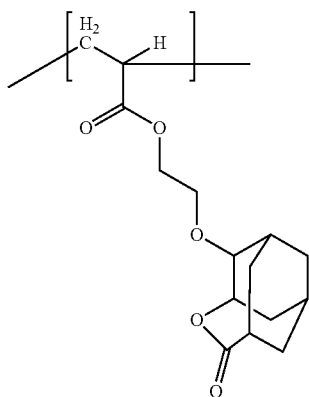
(a3-4-6)



(a3-4-7)

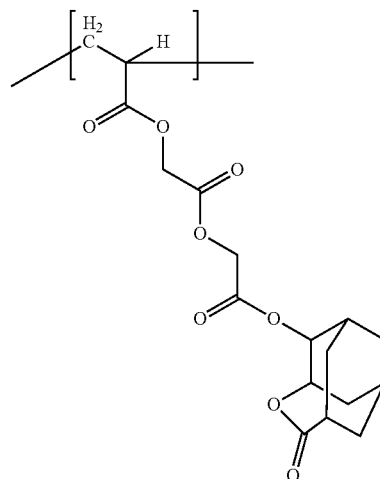


(a3-4-8)

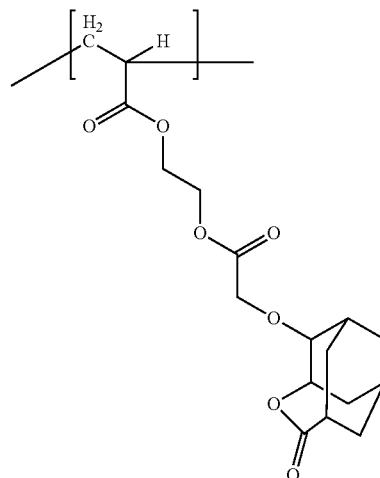


(a3-4-9)

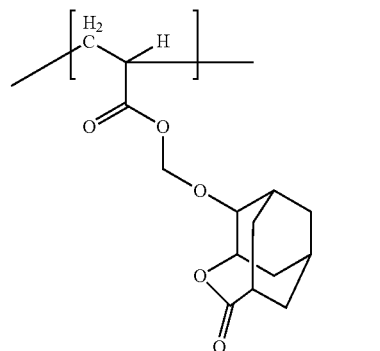
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(a3-4-10)



(a3-4-11)



(a3-4-12)

[0173] The structural unit (a3) is preferably one of formulae (a3-1-1) to (a3-1-4), formulae (a3-2-1) to (a3-2-4), formulae (a3-3-1) to (a3-3-4) and formulae (a3-4-1) to (a3-4-12), more preferably one of formulae (a3-1-1), formula (a3-1-2), formulae (a3-2-3) to (a3-2-4) and formulae (a3-4-1) to (a3-4-2), and still more preferably one of formulae (a3-1-1), (a3-2-3) and (a3-4-2).

[0174] Examples of the monomer from which the structural unit (a3) is derived include those mentioned in US2010/203446A1, US2002/098441A1 and US2013/143157A1.

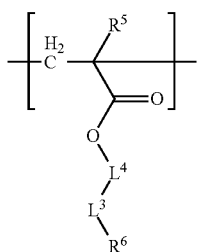
[0175] When Resin (A) comprises the structural unit (a3), its content thereof is preferably 5 to 70% by mole, and more preferably 10 to 65% by mole and more preferably 10 to 60% by mole, based on total molar of all the structural units of the resin.

[0176] Examples of another structural unit having no acid-labile group include a structural unit having a fluorine atom and a structural unit which has a hydrocarbon not being removed therefrom by action of an acid.

[0177] Examples of the structural unit having a fluorine atom include the following one.

[0178] Hereinafter, the structural unit having no acid-labile group but having a halogen atom is referred to as "structural unit (a4)". Halogen atoms for the structural unit (a4) may be a fluorine atom, a chlorine atom, a bromine atom, or an iodine atom. The structural unit (a4) has preferably a fluorine atom.

[0179] Examples of the structural unit (a4) include one represented by formula (a4-0):



wherein R⁵ represents a hydrogen atom or a methyl group;

L⁴ represents a single bond or a C1-C4 aliphatic saturated hydrocarbon group, preferably a C1-C4 aliphatic saturated hydrocarbon group;

L³ represents a C1-C8 perfluoroalkanedyl group or a C3-C12 alicyclic perfluorohydrocarbon group; and

R⁶ represents a hydrogen atom or a fluorine atom.

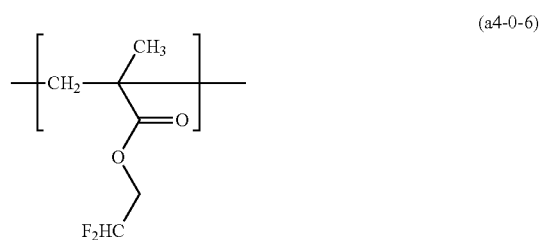
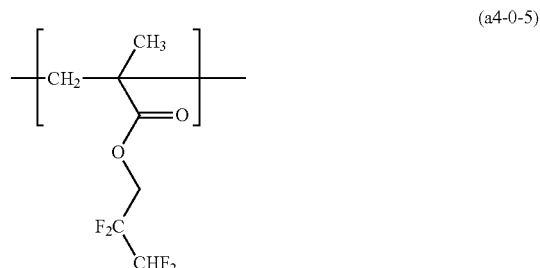
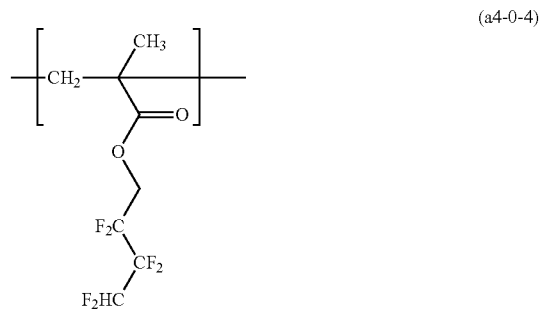
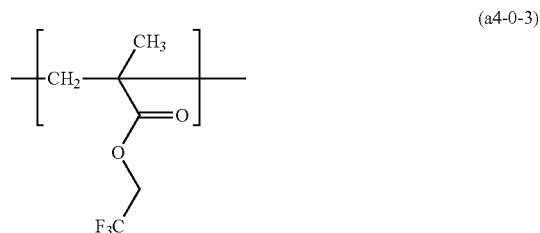
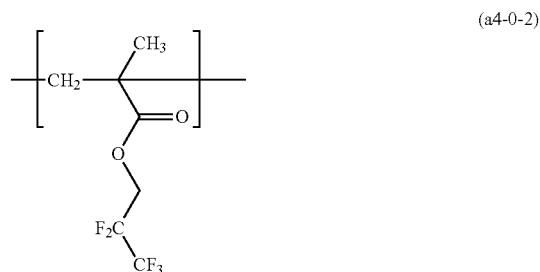
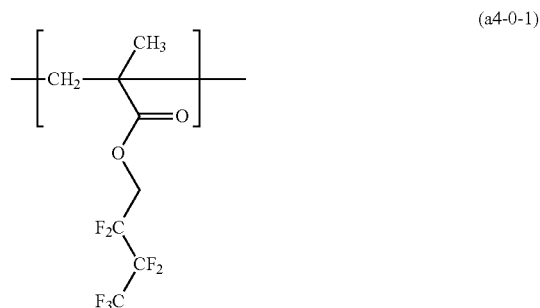
[0180] Examples of the perfluoroalkanedyl group for L³ include a difluoromethylene group, a perfluoroethylene group, a (perfluoroethyl) fluoromethylene group, a perfluoropropane-1,3-diyl group, a perfluoropropane-1,2-diyl group, a perfluorobutane-1,4-diyl group, a perfluoropentane-1,5-diyl group, a perfluorohexane-1,6-diyl group, a perfluoroheptane-1,7-diyl group, and a perfluorooctane-1,8-diyl group.

[0181] Examples of the alicyclic perfluorohydrocarbon group for L³ include a perfluoroadamantandiyl group.

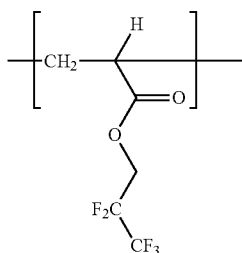
[0182] L⁴ is preferably a single bond, a methylene group or an ethylene group, more preferably a single bond or a methylene group.

[0183] L³ is preferably a C1-C6 perfluoroalkanedyl group, more preferably a C1-C3 perfluoroalkanedyl group.

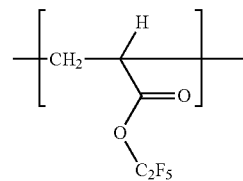
[0184] Examples of the structural unit represented by formula (a4-0) include the following ones and those in which a methyl group has been replaced by a hydrogen atom in each of the following formulae.



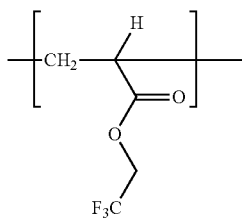
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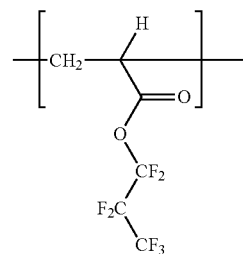
(a4-0-18)



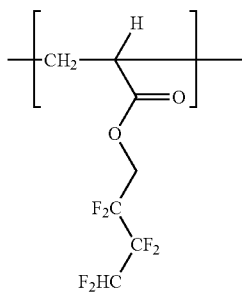
(a4-0-24)



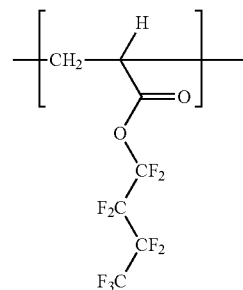
(a4-0-19)



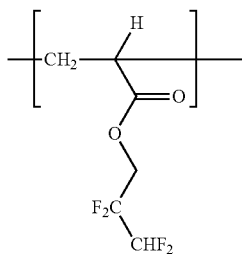
(a4-0-25)



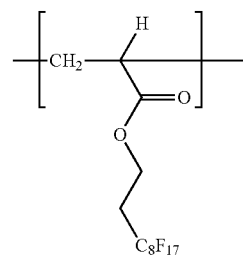
(a4-0-20)



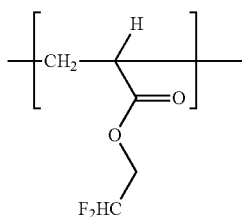
(a4-0-26)



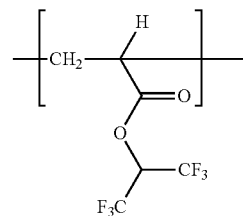
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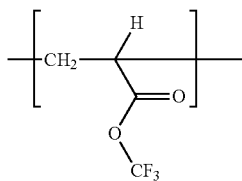
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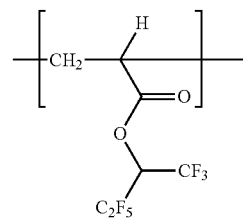
(a4-0-22)



(a4-0-28)

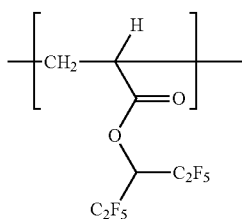


(a4-0-23)

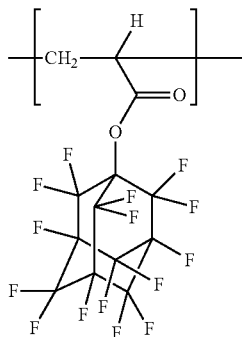


(a4-0-29)

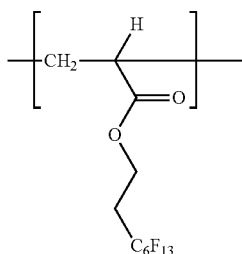
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(a4-0-30)

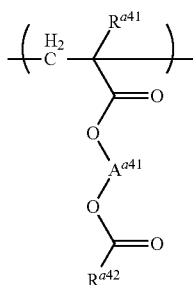


(a4-0-31)



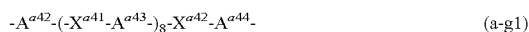
(a4-0-32)

[0185] Examples of the structural unit (a4) include one represented by formula (a4-1):



(a4-1)

wherein R^{a41} represents a hydrogen atom or a methyl group; A^{a41} represents a C1-C6 divalent alkanediyl group which may have a substituent or a moiety represented by formula (a-g1):



in which a represents an integer of 0 to 1, A^{a42} and A^{a42} respectively represent a C1-C5 divalent hydrocarbon group which may have a substituent, A^{a43} represents a single bond or a C1-C5 divalent hydrocarbon group which may have a substituent,

X^{a41} and X^{a42} respectively represent —O—, —CO—, —CO—O—, or —O—CO—, provided that the sum of carbon atoms of A^{a42}, A^{a43}, A^{a44}, X^{a41} and X^{a42} is 6 or less; R^{a42} represents a C1-C20 monovalent hydrocarbon group which may have a substituent, provided that each or both of A^{a41} and R^{a42} have a halogen atom; and A^{a44} is bonded to —O—CO—R^{a42}.

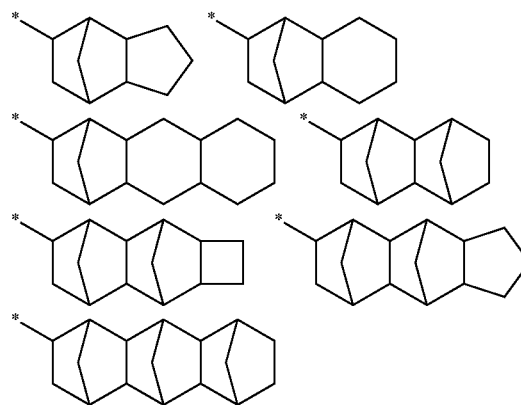
[0186] Examples of halogen atom for formula (a4-1) include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

[0187] The divalent hydrocarbon group is preferably a divalent saturated hydrocarbon group while it may have a carbon-carbon double bond. Examples of the divalent saturated hydrocarbon group include alkanediyl groups which may be a linear or branched one, divalent alicyclic hydrocarbon groups, and combination of them.

[0188] Examples of the monovalent hydrocarbon group for R^{a42} include monovalent chain or cyclic saturated hydrocarbon groups, a monovalent aromatic hydrocarbon group, and combination of them.

[0189] Examples of monovalent chain hydrocarbon group include a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, a decyl group, a dodecyl group, a hexadecyl group, a pentadecyl group, a hexyldecyl group, heptadecyl group and an octadecyl group.

[0190] Examples of monovalent cyclic hydrocarbons include cycloalkyl groups such as a cyclopentyl group, a cyclohexyl group, a cycloheptyl group and a cyclooctyl group; and monovalent polycyclic hydrocarbon groups such as a decahydronaphthyl group, an adamantyl group, a norbornyl group, and the following groups where * represents a binding position.



[0191] Examples of monovalent aromatic hydrocarbon groups include a phenyl group, a naphthyl group, an anthryl group, a biphenyl group, a phenanthryl group and a fluorenyl group.

[0192] The monovalent hydrocarbon group for R^{a42} is preferably monovalent chain and cyclic hydrocarbon groups and combination of them, which may have a carbon-carbon double bond, and more preferably a monovalent chain hydrocarbon group and cyclic hydrocarbon group and combination of them.

[0193] The monovalent chain and cyclic hydrocarbon groups are preferably an alkyl group and an alicyclic hydrocarbon group.

[0194] Examples of the alkyl group include a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a tert-butyl group, a pentyl group, a hexyl group, an octyl group and a 2-ethylhexyl group.

[0195] Examples of the alicyclic hydrocarbon group may be monocyclic or polycyclic. Examples of the monocyclic hydrocarbon group include a cycloalkyl group such as a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a cyclononyl group and a cyclododecyl group. Examples of the polycyclic hydrocarbon group include a decahydronaphthyl group, an adamantyl group, 2-alkyladamantane-2-yl group, a 1-(adamantane-1-yl)alkane-1-yl group, a norbornyl group, methylnorbornyl group and an isobornyl group.

[0196] R^{a42} is preferably a monovalent aliphatic hydrocarbon group which has a substituent, more preferably a monovalent aliphatic hydrocarbon group which has a halogen atom and/or a group represented by formula (a-g3).



in which X^{a43} represents an oxygen atom, a carbonyl group, a carboxyloxy group or an oxycarbonyl group, A^{a45} represents a C3-C17 monovalent saturated hydrocarbon group which may have a fluorine atom.

[0197] When R^{a42} is a monovalent saturated hydrocarbon group which has a group represented by formula (a-g3), R^{a42} has preferably 15 or less carbon atoms, more preferably 12 or less carbon atoms in total including the carbon atoms of formula (a-g3). If R^{a42} has a group represented by formula (a-g3), the number of the group is preferably 1.

[0198] The monovalent saturated hydrocarbon group which has a group represented by formula (a-g3) is preferably a group represented by formula (a-g2):



in which A^{a46} represents a C3-C17 divalent saturated hydrocarbon group which may have a fluorine atom, X^{a44} represents a carboxyloxy group or an oxycarbonyl group, and A^{a47} represents a C3-C17 divalent saturated hydrocarbon group which may have a fluorine atom, provided that A^{a46} , A^{a47} and X^{a44} have 18 or less of carbon atoms in total and one or both of A^{a46} and A^{a47} have a fluorine atom.

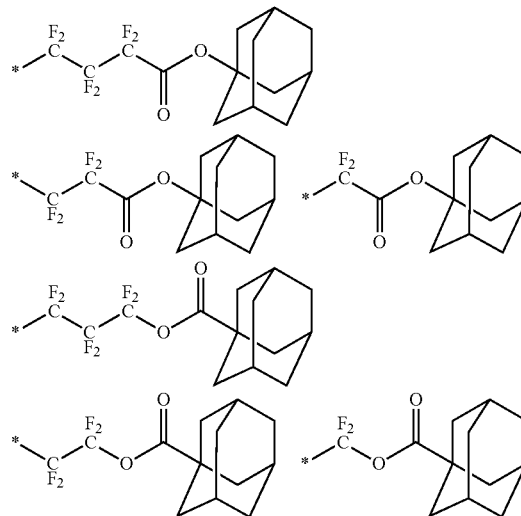
[0199] The halogen-containing saturated hydrocarbon group represented by R^{a42} is preferably a monovalent fluorine-containing saturated hydrocarbon group, more preferably a perfluoroalkyl group or a perfluorocycloalkyl group, still more preferably a C1-C6 perfluoroalkyl group, and further more preferably a C1-C3 perfluoroalkyl group.

[0200] Examples of perfluoroalkyl group include a perfluoromethyl group, a perfluoroethyl group, a perfluoropropyl group, a perfluorobutyl group, a perfluoropentyl group, a perfluorohexyl group, a perfluoroheptyl group, and a perfluorooctyl group. Examples of the perfluorocycloalkyl group include perfluorocyclohexyl group.

[0201] The divalent saturated hydrocarbon group represented by A^{a46} has preferably 1 to 6, more preferably 1 to 3 carbon atoms.

[0202] The monovalent saturated hydrocarbon group represented by A^{a47} has preferably 4 to 15, more preferably 5 to 12 carbon atoms. A^{a47} is more preferably a cyclohexyl group or an adamantyl group.

[0203] Examples of the moiety represented by $-A^{a46}-X^{a44}-A^{a47}$ include the following ones.



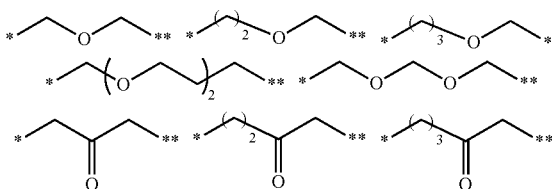
[0204] In each formula, * represents a binding position to a carbonyl group.

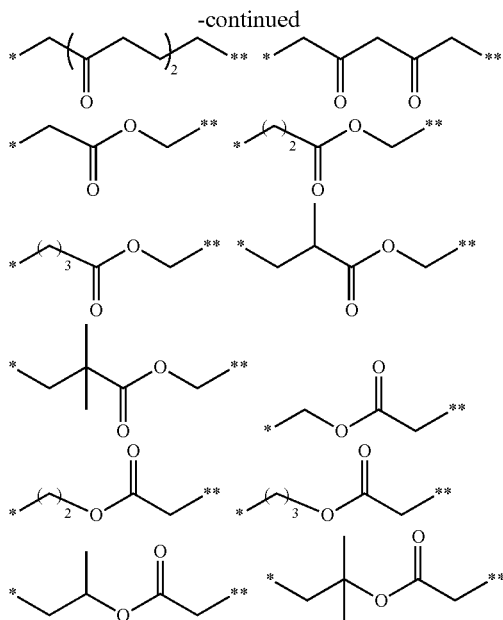
[0205] Examples of A^{a41} typically include a C1-C6 alkanediyl group which may be a linear chain or branched chain. Specific examples of them include linear chain alkanediyl groups such as a methylene group, an ethylene group, a propane-1,3-diyl group, a butane-1,4-diyl group, a pentane-1,5-diyl group, or a hexane-1,6-diyl group; and branched chain alkanediyl groups such as a propane-1,3-diyl group, a butane-1,3-diyl group, a 1-methylbutane-1,2-diyl group, or a 2-methylbutane-1,4-diyl group. Examples of the substituents which such alkanediyl group may have include a hydroxy group or a C1-C6 alkoxy group.

[0206] A^{a42} is preferably a C1-C4 alkanediyl group, more preferably a C2-C4 alkanediyl group, and still more preferably an ethylene group. Examples of the alkanediyl group represented by A^{a42} , A^{a43} and A^{a44} include a methylene group, an ethylene group, a propane-1,3-diyl group, a butane-1,4-diyl group, a 2-methylpropane-1,3-diyl group, or a 2-methylbutane-1,4-diyl group. Examples of the substituents which such alkanediyl group may have include a hydroxy group or a C1-C6 alkoxy group.

[0207] X^{a42} represents $-O-$, $-CO-$, $-CO-O-$, or $-O-CO-$.

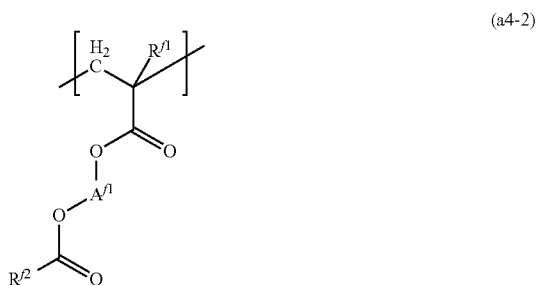
[0208] Examples of the moiety represented by formula (a-g1) where X^{a42} is an oxygen atom, a carbonyl group, a carboxyloxy group or an oxycarbonyl group include the following ones:





in which * and ** represent binding sites, and ** represents a binding site to $-\text{O}-\text{CO}-\text{R}^{\alpha 2}$.

[0209] The structural unit represented by formula (a4-1) is preferably one represented by formula (a4-2) or (a4-3).



[0210] In formula, R^1 represents a hydrogen atom or a methyl group.

[0211] A^1 represents a C1-C6 alkanediyl group.

[0212] R^2 represents a C1-C10, monovalent hydrocarbon group having a fluorine atom.

[0213] The alkanediyl groups represented by A^1 may be a linear chain or branched chain. Specific examples of them include linear chain alkanediyl groups such as a methylene group, an ethylene group, a propane-1,3-diyl group, a butane-1,4-diyl group, a pentane-1,5-diyl group, or a hexane-1,6-diyl group; and branched chain alkanediyl groups such as a propane-1,3-diyl group, a butane-1,3-diyl group, a 1-methylbutane-1,2-diyl group, or a 2-methylbutane-1,4-diyl group. Examples of the substituents which such alkanediyl group may have include a hydroxy group or a C1-C6 alkoxy group.

[0214] The monovalent hydrocarbon group represented by R^2 includes monovalent saturated hydrocarbon groups and monovalent aromatic hydrocarbon groups. The monovalent saturated hydrocarbon groups may be a chain or cyclic saturated hydrocarbon group, or a combined group of them.

[0215] The monovalent saturated hydrocarbon groups are preferably an alkyl group or a monovalent alicyclic hydrocarbon group.

[0216] Examples of the alkyl group include a methyl group, an ethyl group, n-propyl group, isopropyl group, n-butyl group, sec-butyl group, a tert-butyl group, a pentyl group, a hexyl group and 2-ethylhexyl group.

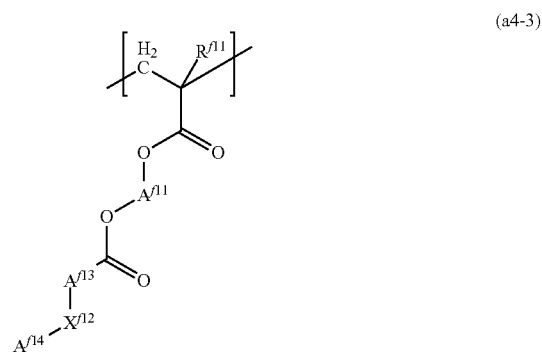
[0217] The monovalent alicyclic hydrocarbon groups may be monocyclic or polycyclic groups. Examples of monovalent monocyclic hydrocarbon groups include a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group, a methylcyclohexyl group, a dimethylcyclohexyl group, a cycloheptyl group, a cyclooctyl group, a cycloheptyl group and a cyclodecyl group.

[0218] Examples of monovalent polycyclic hydrocarbon groups include a decahydronaphthyl group, an adamantyl group, a norbornyl group, and an isobornyl group.

[0219] Examples of the combined group of the above-mentioned hydrocarbon group include a 2-alkyladamantane-2-yl group, a 1-(adamantane-1-yl)alkane-1-yl group, and a methylnorbornyl group. Examples of monovalent hydrocarbon groups having a fluorine atom for R^2 include monovalent fluoroalkyl groups and monovalent fluorine atom-containing alicyclic hydrocarbon groups.

[0220] Specific examples of monovalent fluoroalkyl groups include a fluoromethyl group, a trifluoromethyl group, 1,1-difluoroethyl group, 2,2-difluoroethyl group, 2,2,2-trifluoroethyl group, perfluoroethyl group, 1,1,2,2-tetrafluoropropyl group, 1,1,2,2,3,3-hexafluoropropyl group, perfluoroethylmethyl group, 1-(trifluoromethyl)-1,2,2,2-tetrafluoroethyl group, perfluoropropyl group, 1,1,2,2-tetrafluorobutyl group, 1,1,2,2,3,3-hexafluorobutyl group, 1,1,2,2,3,3,4,4-octafluorobutyl group, perfluorobutyl group, 1,1-bis(trifluoro) methyl-2,2,2-trifluoroethyl group, 2-(perfluoropropyl)ethyl group, 1,1,2,2,3,3,4,4-octafluoropentyl group, perfluoropentyl group, 1,1,2,2,3,3,4,4,5,5-decafluoropentyl group, 1,1-bis(trifluoromethyl)-2,2,3,3-pentafluoropropyl group, 2-(perfluorobutyl)ethyl group, 1,1,2,2,3,3,4,4,5,5-decafluorohexyl group, 1,1,2,2,3,3,4,4,5,5,6,6-dodecafluorohexyl group, a perfluoropentylmethyl group and a perfluorohexyl group. Specific examples of monovalent fluorine-containing alicyclic hydrocarbon groups include fluorocycloalkyl groups such as a perfluorocyclohexyl group and a perfluoroadamantyl group.

[0221] In formula (a4-2), A^1 is preferably a C2-C4 alkylene group, and more preferably an ethylene group. R^2 is preferably a C1-C6 fluoroalkyl group.



[0222] In formula, R^11 represents a hydrogen atom or a methyl group.

[0223] A^11 represents a C1-C6 alkanediyl group.

[0224] A^13 represents a C1-C18 divalent saturated hydrocarbon group which may have a fluorine atom.

[0225] X^{12} represents a carbonyloxy group or an oxycarbonyl group.

[0226] A^{14} represents a C1-C17 divalent saturated hydrocarbon group which may have a fluorine atom, provided that one or both of A^{13} and A^{14} represents a fluorine-containing saturated hydrocarbon group. Examples of the alkanediyl group represented by A^{11} include those as referred to for A^{12} .

[0227] As to A^{13} , the divalent saturated hydrocarbon group includes chain saturated hydrocarbon groups, cyclic saturated hydrocarbon groups and combined groups of these groups.

[0228] As to A^{13} , the divalent saturated hydrocarbon group which may have a fluorine atom is preferably a divalent saturated chain hydrocarbon group which may have a fluorine atom, more preferably a perfluoroalkanediyl group.

[0229] Examples of the divalent aliphatic hydrocarbon group which may have a fluorine atom include an alkanediyl group such as a methyl group, an ethylene group, a propanediyl group, a butanediyl group and pentanediyl group; and a perfluoroalkanediyl group such as a difluoromethylene group, a perfluoroethylene group, a perfluoropropanediyl group, a perfluorobutanediyl group and perfluoropentanediyl group.

[0230] The divalent cyclic hydrocarbon group which may have a fluorine atom may be a divalent monocyclic or polycyclic group.

[0231] Examples of the divalent monocyclic hydrocarbon group which may have a fluorine atom include a cyclohexanediyl group and a perfluorocyclohexanediyl group.

[0232] Examples of the divalent polycyclic hydrocarbon group which may have a fluorine atom include an adamantanediyl group, norbornanediyl group, and a perfluoroadamantanediyl group.

[0233] In the group represented by A^{14} , the monovalent saturated hydrocarbon group includes chain saturated hydrocarbon groups, cyclic saturated hydrocarbon groups and combined groups of these saturated hydrocarbon groups.

[0234] As to A^{14} , the monovalent aliphatic hydrocarbon group which may have a fluorine atom is preferably a monovalent saturated aliphatic hydrocarbon group which may have a fluorine atom, more preferably a perfluoroalkanediyl group.

[0235] Examples of the monovalent aliphatic hydrocarbon group which may have a fluorine atom include a trifluoromethyl group, a fluoromethyl group, a methyl group, a perfluoroethyl group, a 1,1,1-trifluoroethyl group, a 1,1,2,2-tetrafluoroethyl group, an ethyl group, a perfluoropropyl group, a 1,1,2,2-pentafluoropropyl group, propyl group, a perfluorobutyl group, 1,1,2,2,3,3,4,4-octafluorobutyl group, a butyl group, a perfluoropentyl group, 1,1,1,2,2,3,3,4,4-nonafluoropentyl group, a pentyl group, a hexyl group, a perfluorohexyl group, a heptyl group, a perfluoroheptyl group, an octyl group and a perfluorooctyl group.

[0236] The monovalent cyclic hydrocarbon group which may have a fluorine atom may be monocyclic or polycyclic monovalent group.

[0237] Examples of the monovalent monocyclic hydrocarbon group which may have a fluorine atom include a cyclopropyl group, cyclopentyl group, cyclohexyl group, and perfluorocyclohexyl group.

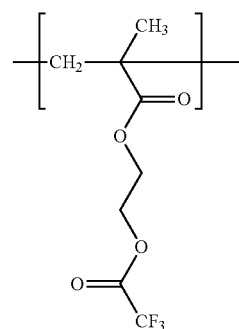
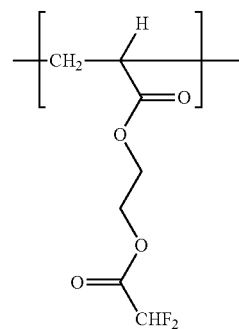
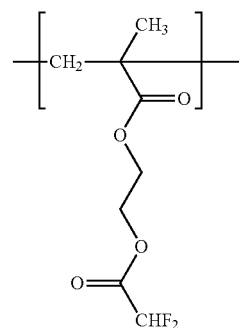
[0238] Examples of the monovalent polycyclic hydrocarbon group which may have a fluorine atom include an adamantyl group, a norbornyl group, and a perfluoroadamantyl group.

[0239] Examples of the combined groups of the above mentioned aliphatic hydrocarbon group include a cyclopropylmethyl group, a cyclobutylmethyl group, an adamantylmethyl group, a norbornylmethyl group and a perfluoroadamantylmethyl group.

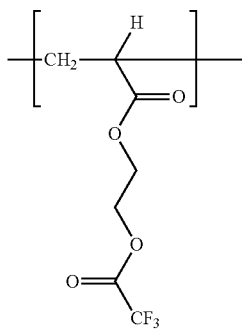
[0240] In formula (a4-3), A^{11} is preferably an ethylene group.

[0241] The divalent aliphatic hydrocarbon group represented by A^{13} has preferably 6 or less, more preferably 2 to 3, of carbon atoms. The monovalent aliphatic hydrocarbon group represented by A^{14} has preferably 3 to 12, more preferably 3 to 10, of carbon atoms. A^{14} has preferably a C3-C12 monovalent alicyclic hydrocarbon group, more preferably a cyclopropylmethyl group, a cyclopentyl group, a cyclohexyl group, a norbornyl group or an adamantyl group.

[0242] Examples of the structural unit of formula (a4-2) include preferably those represented by formulae (a4-1-1) to (a4-1-22).

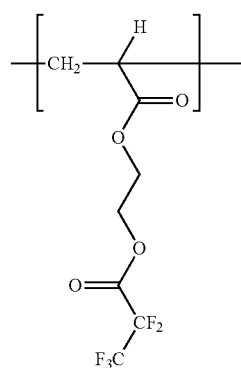


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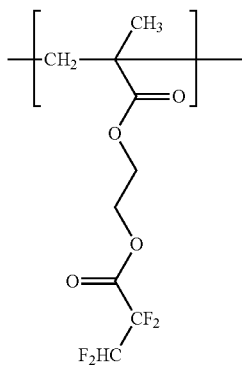


(a4-1-4)

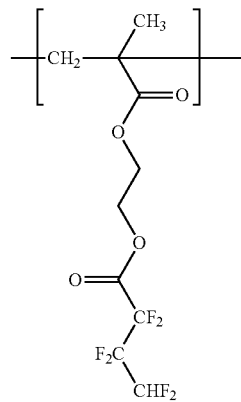
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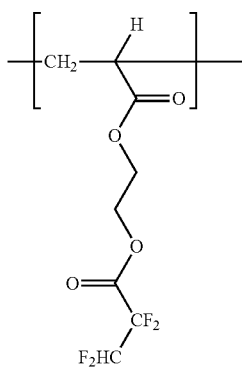
(a4-1-8)



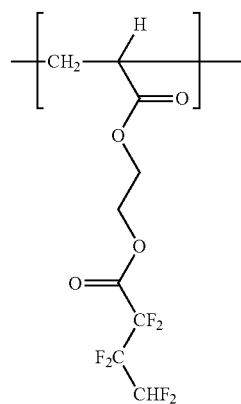
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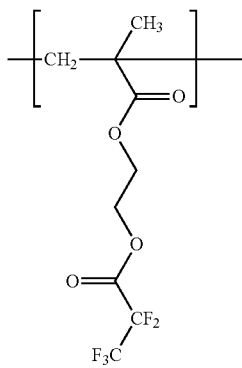
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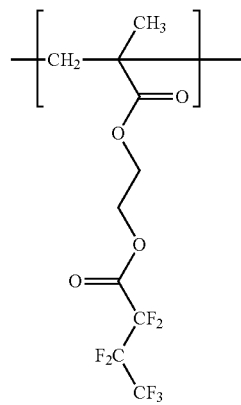
(a4-1-6)



(a4-1-10)

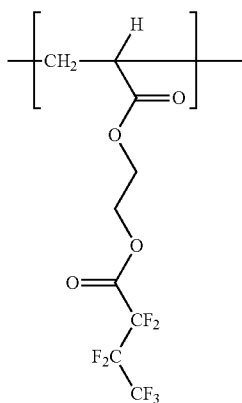


(a4-1-7)

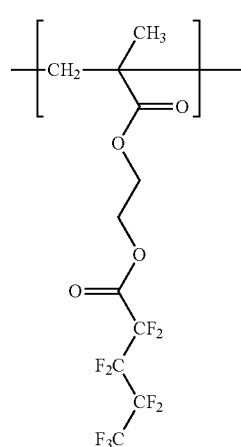


(a4-1-11)

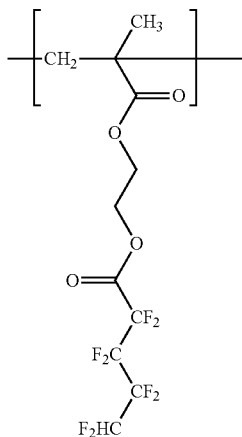
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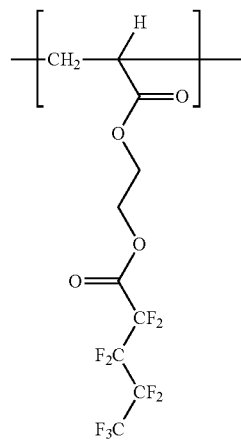
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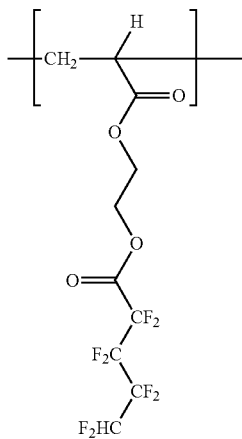
(a4-1-13)



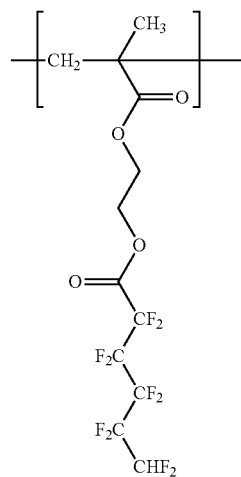
(a4-1-16)



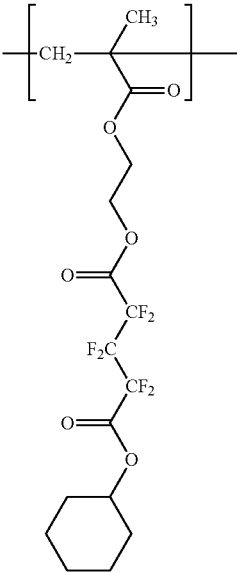
(a4-1-14)



(a4-1-17)

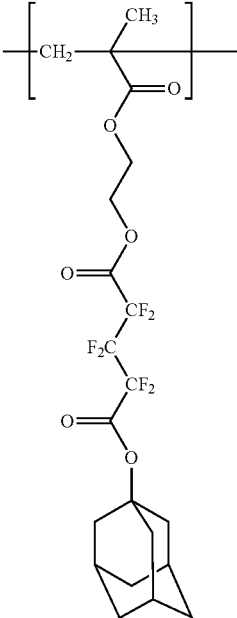


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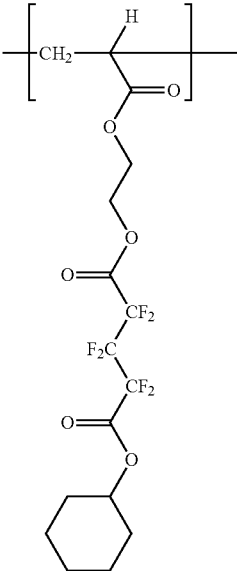
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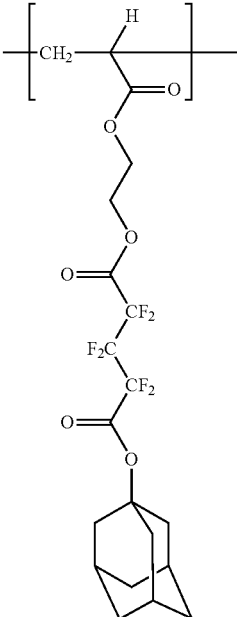


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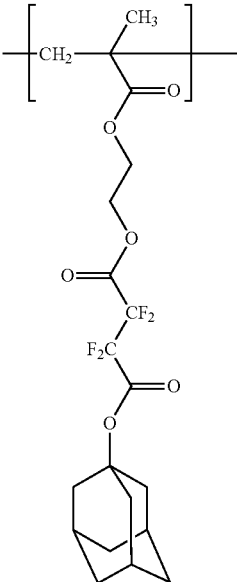
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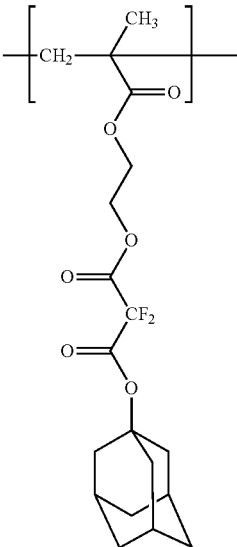
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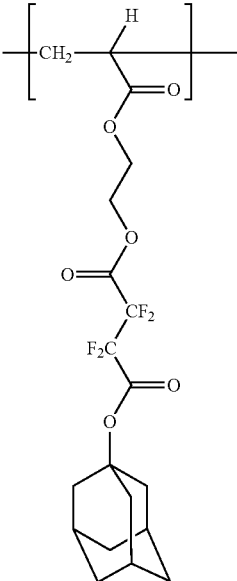
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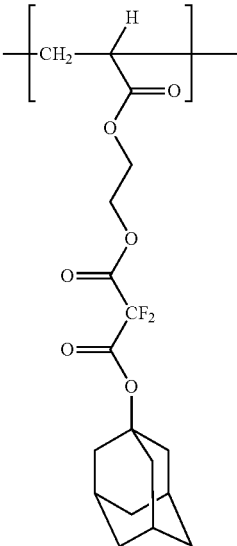
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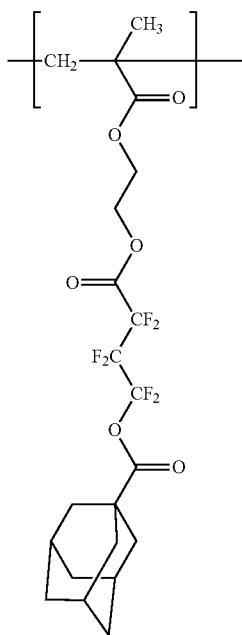
(a4-1'-12)



(a4-1'-14)

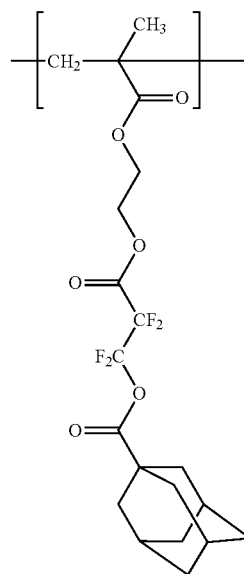


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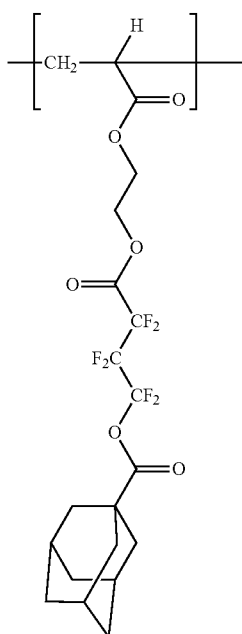


(a4-1'-15)

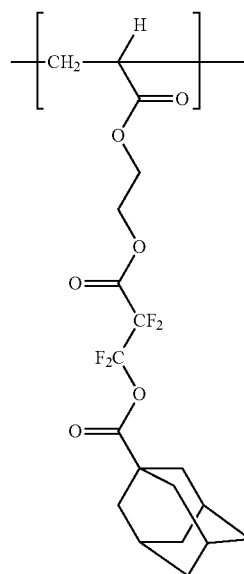
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(a4-1'-17)

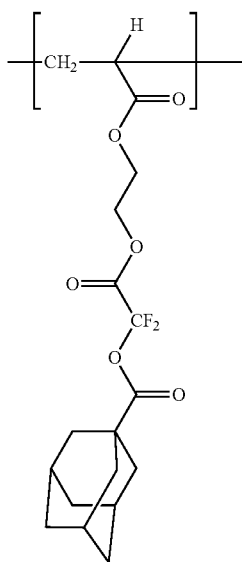
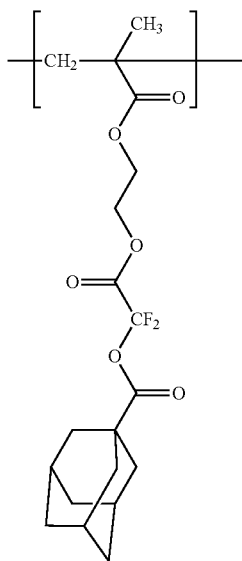


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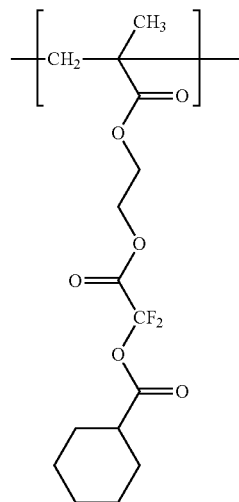
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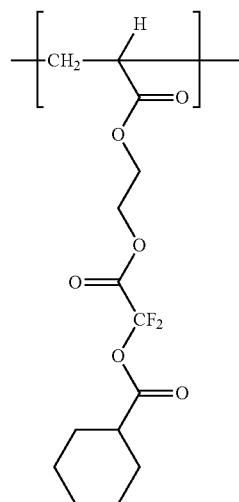


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(a4-1'-19)



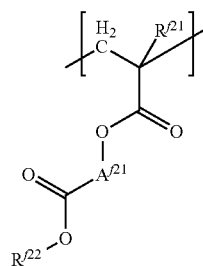
(a4-1'-21)



(a4-1'-22)

(a4-1'-20)

[0244] Another example of the structural unit (a4) includes those represented by formula (a4-4).



(a4-4)

[0245] In formula (a4-4), wherein R²¹ represents a hydrogen atom or a methyl group;

[0246] A²¹ represents $-(CH_2)_{j1}-$, $-(CH_2)_{j2}-O-$, $(CH_2)_{j3}-$ or $-(CH_2)_{j4}-CO-O-(CH_2)_{j5}-$ where j₁, j₂, j₃, j₄ or j₅ each independently represent an integer of 1 to 6; and

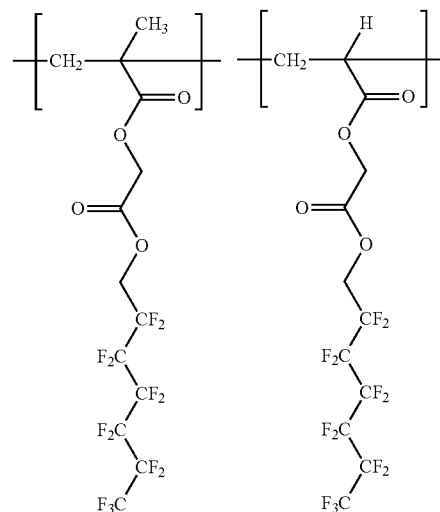
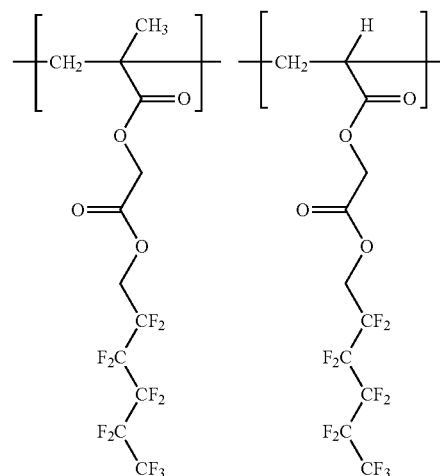
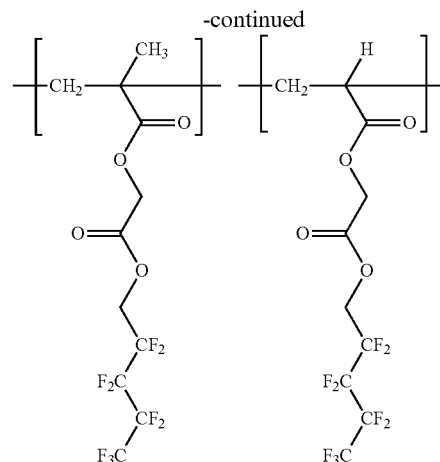
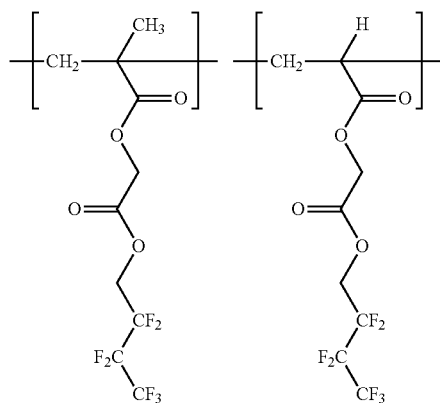
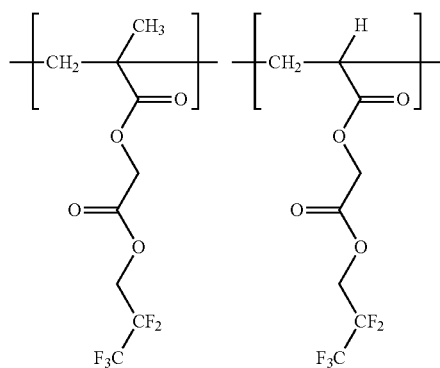
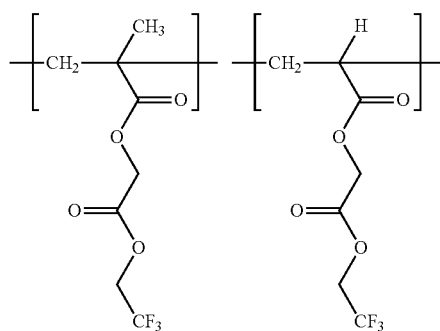
[0247] R²² represents a C1-C10 monovalent hydrocarbon group having a fluorine atom.

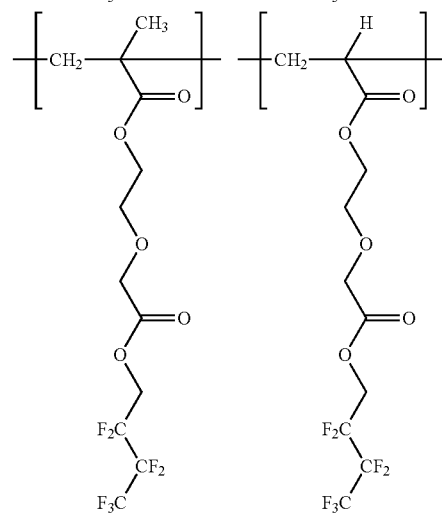
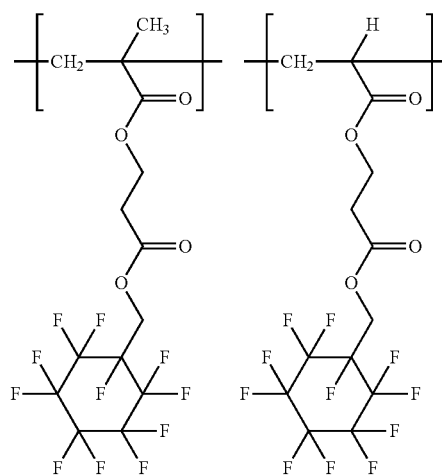
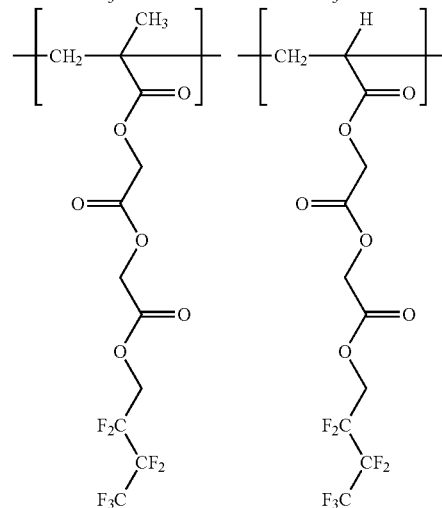
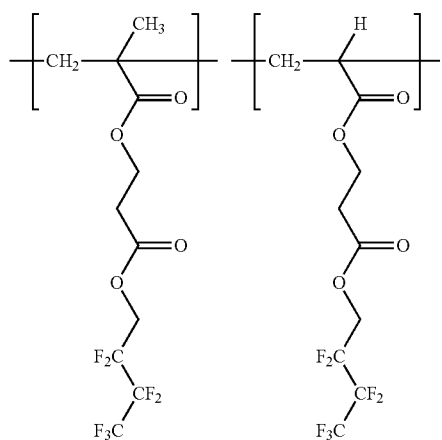
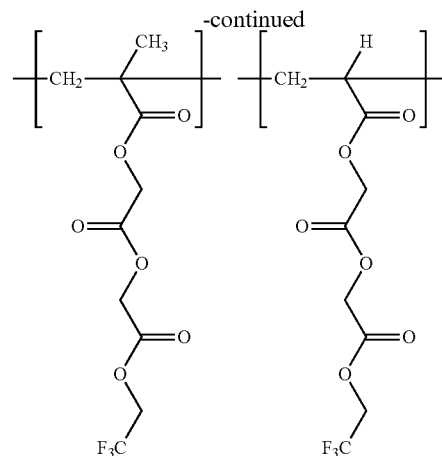
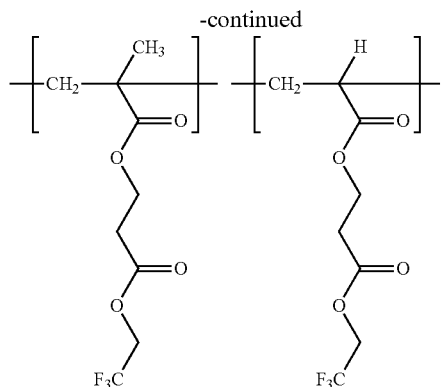
[0248] For R^{22} , examples of monovalent hydrocarbon group having a fluorine atom include those as referred to for R^{22} .

[0249] R^{22} is preferably a C1-C10 monovalent alkyl group having a fluorine atom or a C3-C10 monovalent alicyclic hydrocarbon group having a fluorine atom, more preferably a C1-C10 monovalent alkyl group having a fluorine atom, and still more preferably a C1-C6 monovalent alkyl group having a fluorine atom.

[0250] In formula (a4-4), A^{21} is preferably $-(CH_2)_{j1}$, more preferably a methylene or ethylene group, and still more preferably a methylene group.

[0251] Examples of the structural unit represented by formula (a4-4) include preferably the following ones.





[0252] When Resin (A) comprises the structural unit (a4), its content is preferably 1 to 20 by mole, more preferably 2 to 15% by mole and still more preferably 3 to 10% based on 100% by mole of all the structural units of the resin.

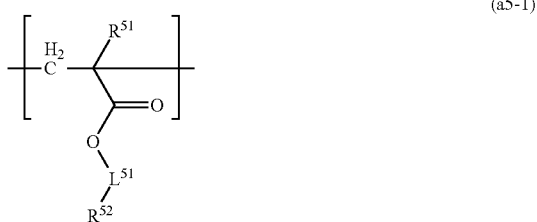
[0253] Other examples of the structural unit having no acid-labile group include one having an acid-stable hydrocarbon group.

[0254] Herein, the term “acid-stable hydrocarbon group” means such a hydrocarbon group that is not removed from the structural unit having the group by action of an acid generated from an acid generator as described later.

[0255] The acid-stable hydrocarbon group may be a linear, branched or cyclic hydrocarbon group.

[0256] The structural unit which has a hydrocarbon not being removed therefrom by action of an acid may have a linear, branched or cyclic hydrocarbon, preferably an alicyclic hydrocarbon group.

[0257] Examples of the structural unit having an acid-stable hydrocarbon group include one represented by formula (a5-1):



where R^{51} represents a hydrogen atom or a methyl group; R^{52} represents a C3-C18 monovalent alicyclic hydrocarbon group which may have a C1-C8 monovalent aliphatic hydrocarbon group as a substituent, provided that the alicyclic hydrocarbon group has no substituent on the carbon atom bonded to L^{51} ; and

[0258] L^{51} represents a single bond or a C1-C18 divalent saturated hydrocarbon group where a methylene group can be replaced by an oxygen atom or carbonyl group.

[0259] The alicyclic hydrocarbon group represented by R^{52} may be monocyclic or polycyclic one.

[0260] Examples of the alicyclic hydrocarbon group include a monocyclic hydrocarbon group such as a C3-C18 cycloalkyl group (e.g. a cyclopropyl group, a cyclobutyl group, a cyclopentyl group, a cyclohexyl group) and a polycyclic alicyclic hydrocarbon group such as an adamantyl group, or a norbornyl group.

[0261] Examples of the aliphatic hydrocarbon group include an alkyl groups such as a methyl group, an ethyl group, n-propyl group, isopropyl group, n-butyl group, sec-butyl group, tert-butyl group, a pentyl group, a hexyl group, an octyl group and 2-ethylhexyl group.

[0262] Examples of the alicyclic hydrocarbon group having a substituent include a 3-hydroxyadamantyl group, and a 3-methyladamantyl group. R^{52} is preferably a C3-C18 unsubstituted alicyclic hydrocarbon group, more preferably an adamantyl group, a norbornyl group or a cyclohexyl group.

[0263] Examples of the divalent saturated hydrocarbon group represented by L^{51} include divalent aliphatic hydrocarbon groups and divalent alicyclic hydrocarbon groups, preferably divalent aliphatic hydrocarbon groups.

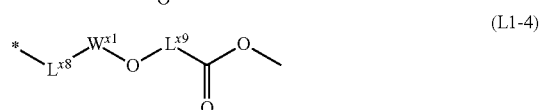
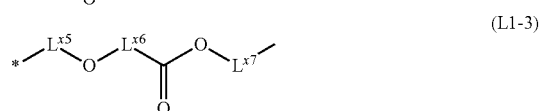
[0264] Examples of divalent aliphatic hydrocarbon groups include alkanediyl groups such as a methylene group, an ethylene group, a propanediyl group, a butanediyl group and a pentanediyl group.

[0265] The divalent alicyclic hydrocarbon groups may be monocyclic or polycyclic one.

[0266] Examples of divalent monocyclic hydrocarbon groups include cycloalkanediyl groups such as a cyclopent-

anediyl group and a cyclohexanediyl group. Examples of divalent polycyclic alicyclic hydrocarbon groups include an adamantanediyl group and a norbornanediyl group.

[0267] Examples of the divalent hydrocarbon group where a methylene group has been replaced by an oxygen atom or carbonyl group include those represented by formulae (L1-1) to (L1-4).



[0268] In these formulae, * represents a binding position to an oxygen atom.

[0269] X^{x1} is a carbonyloxy group or an oxycarbonyl group; and

[0270] L^{x1} is a C1-C16 divalent saturated hydrocarbon group, and L^{x2} is a single bond or a C1-C15 divalent saturated hydrocarbon group, provided that the total number of the carbon atoms in L^{x1} and L^{x2} is 16 or less.

[0271] L^{x3} is a C1-C17 divalent saturated hydrocarbon group, and L^{x4} is a single bond or a C1-C16 divalent saturated hydrocarbon group, provided that the total number of the carbon atoms in L^{x3} and L^{x4} is 17 or less.

[0272] L^{x5} is a C1-C15 divalent saturated hydrocarbon group, and L^{x6} and L^{x7} are a single bond or a C1-C14 divalent saturated hydrocarbon group, provided that the total number of the carbon atoms in L^{x5} , L^{x6} and L^{x7} is 15 or less.

[0273] L^{x8} and L^{x9} are each independently a single bond or a C1-C12 divalent saturated hydrocarbon group, and W^{x1} is a C3-C15 divalent cyclic saturated hydrocarbon group, provided that the total number of the carbon atoms in L^{x8} , L^{x9} and W^{x1} is 15 or less.

[0274] L^{x1} is preferably a C1-C8 divalent saturated hydrocarbon group, more preferably a methylene group or an ethylene group.

[0275] L^{x2} is preferably a single bond, or a C1-C8 divalent saturated hydrocarbon group, more preferably a single bond.

[0276] L^{x3} is preferably a C1-C8 divalent saturated hydrocarbon group, more preferably a methylene group or an ethylene group.

[0277] L^{x4} is preferably a single bond or a C1-C8 divalent saturated hydrocarbon group, more preferably a single bond, a methylene group or an ethylene group.

[0278] L^{x5} is preferably a C1-C8 divalent saturated hydrocarbon group, more preferably a methylene group or an ethylene group.

[0279] L^{x6} is preferably a single bond or a C1-C8 divalent saturated hydrocarbon group, more preferably a methylene group or an ethylene group.

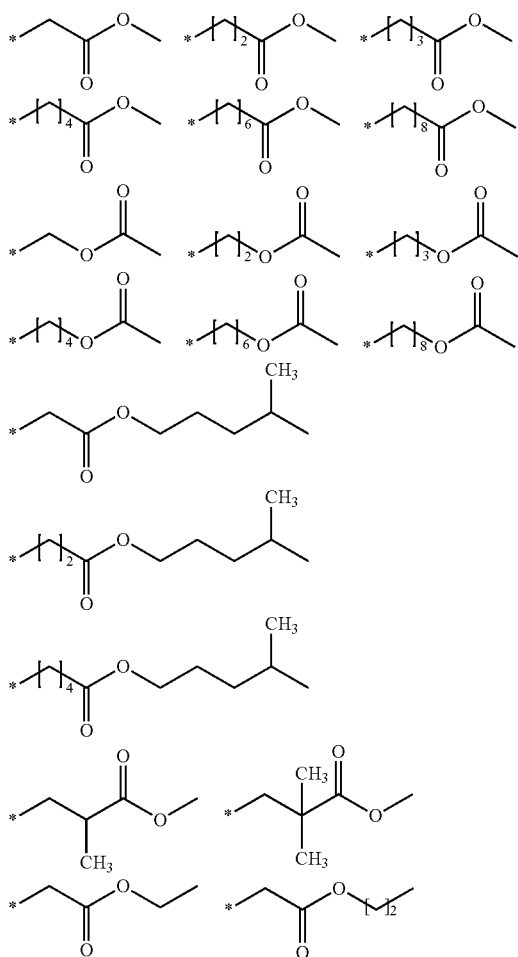
[0280] L^{x7} is preferably a single bond or a C1-C8 divalent saturated hydrocarbon group, more preferably a methylene group or an ethylene group.

[0281] L^{x8} is preferably a single bond or a C1-C8 divalent saturated hydrocarbon group, more preferably a single bond or a methylene group.

[0282] L^{x9} is preferably a single bond or a C1-C8 divalent saturated hydrocarbon group, more preferably a single bond or a methylene group.

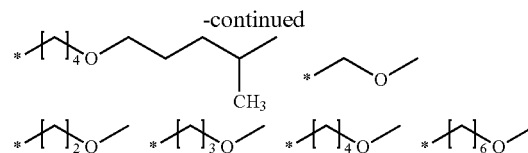
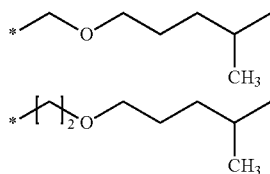
[0283] W^{x7} is a preferably C3-C10 divalent cyclic saturated hydrocarbon group, more preferably a cyclohexanedyl group or an adamantanedyl group.

[0284] Examples of the divalent hydrocarbon group represented by formula (L1-1) include the following ones.



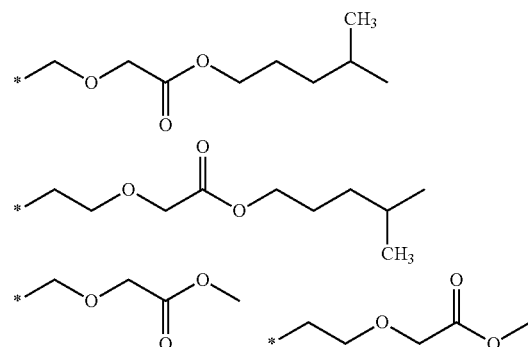
[0285] In these formulae, * represents a binding position to an oxygen atom.

[0286] Examples of the divalent hydrocarbon group represented by formula (L1-2) include the following ones.



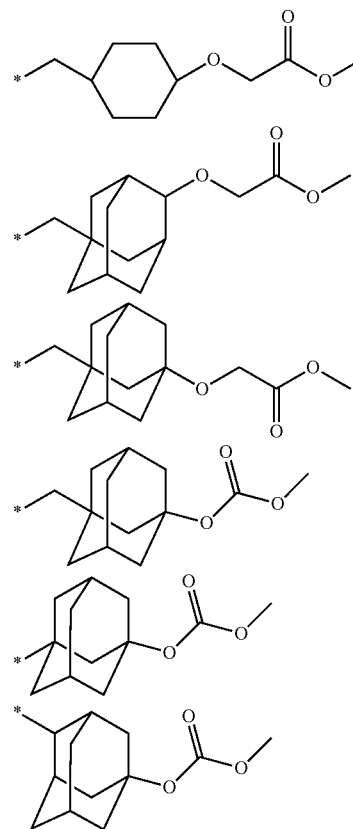
[0287] In these formulae, * represents a binding position to an oxygen atom.

[0288] Examples of the divalent hydrocarbon group represented by formula (L1-3) include the following ones.



[0289] In these formulae, * represents a binding position to an oxygen atom.

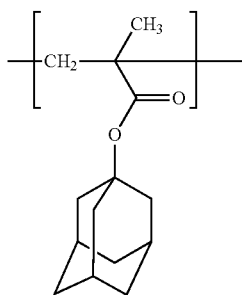
[0290] Examples of the divalent hydrocarbon group represented by formula (L1-4) include the following ones.



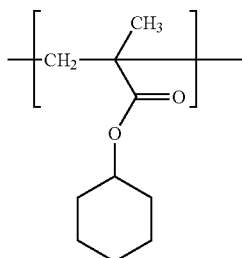
[0291] In these formulae, * represents a binding position to an oxygen atom.

[0292] L^{51} is preferably a single bond or a group represented by formula (L1-1).

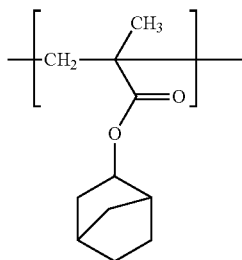
[0293] Examples of the structural unit represented by formula (a5-1) include the following ones and those where a methyl group has been replaced by a hydrogen atom in each formula.



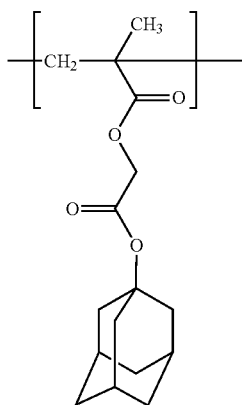
(a5-1-1)



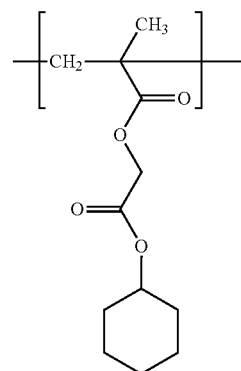
(a5-1-2)



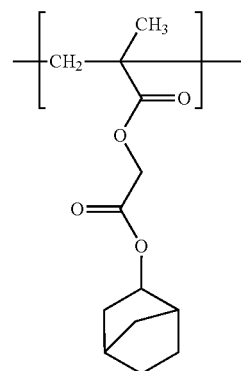
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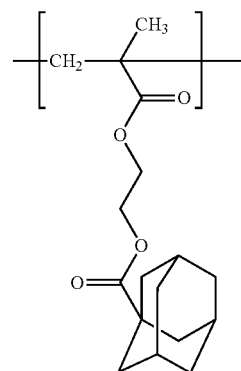
(a5-1-4)



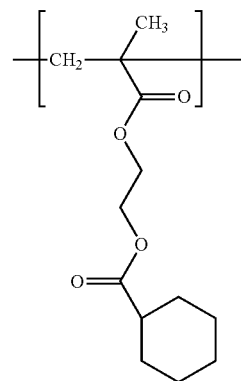
(a5-1-5)



(a5-1-6)



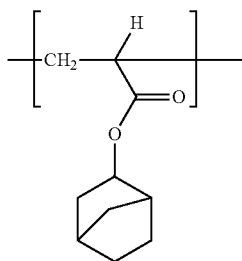
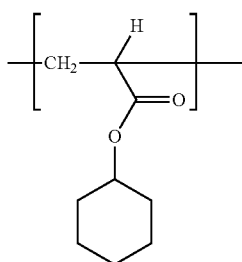
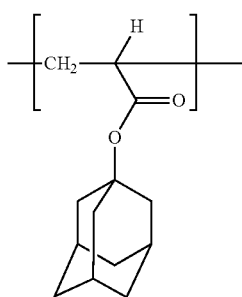
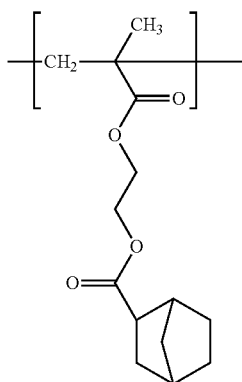
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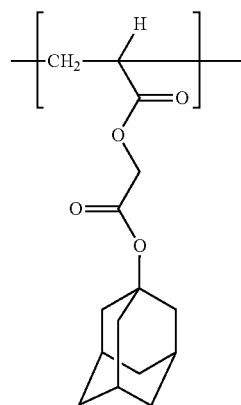
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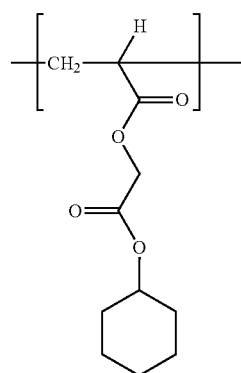


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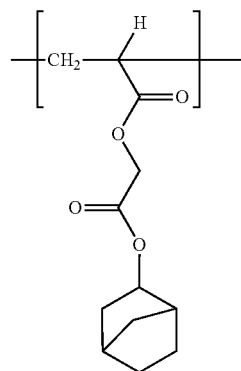
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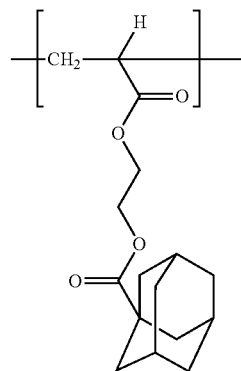
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(a5-1-11)



(a5-1-12)



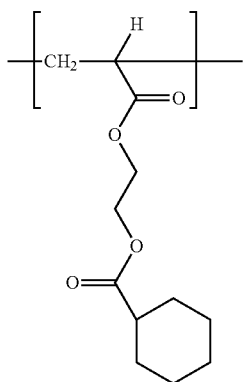
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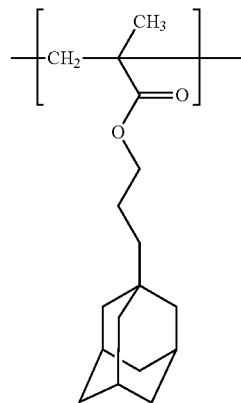
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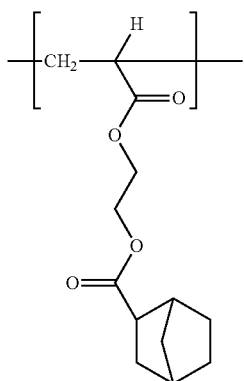
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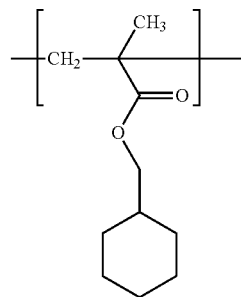
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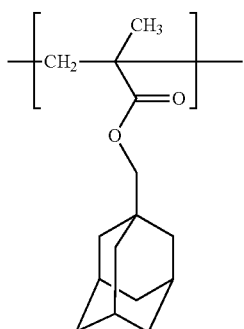
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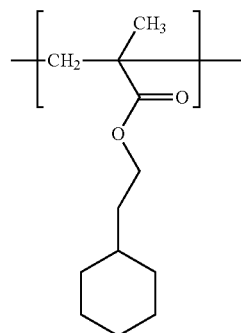
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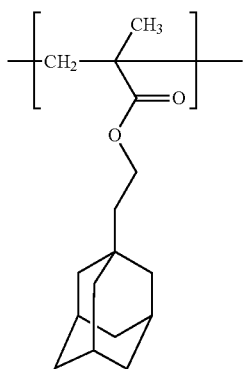
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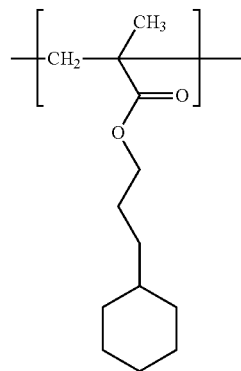
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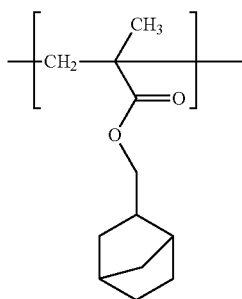
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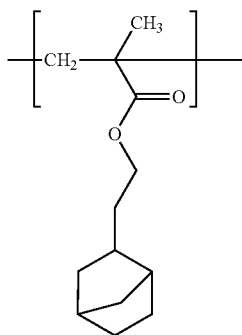
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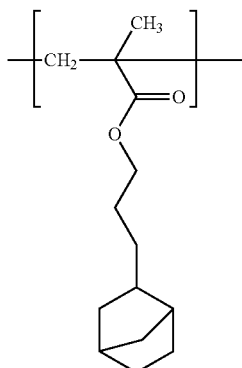
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(a5-1-26)



(a5-1-27)

[0294] Resin (A) comprises preferably the structural unit (a1) and the structural unit having no acid-labile group.

[0295] In Resin (A), the structural unit (a1) is one of the structural unit (a1-1) and the structural unit (a1-2), more preferably the structural unit (a1-2). The structural unit (a1-2) is preferably which comprises a cyclohexyl group or a cyclopentyl group.

[0296] The structural unit having no acid-labile group is preferably one of the structural unit (a2) and the structural unit (a3). The structural unit (a2) is preferably the structural unit (a2-1). The structural unit (a3) is preferably one of the structural unit (a3-1), the structural unit (a3-2) and the structural unit (a3-4). Resin (A) comprises preferably the structural unit (a1) derived from a structural unit having an adamantyl group, preferably structural unit (a1-1). The content of the structural unit having an adamantyl group is preferably 15% by mole or more of the total amount of the structural unit (a1). The more is the structural unit having an adamantyl group, the more improved is the resistance of the photoresist film to dry etching.

[0297] Resin (A) can be produced according to known polymerization methods such as radical polymerization.

[0298] The resin has usually 2,000 or more of the weight-average molecular weight, preferably 2,500 or more of the weight-average molecular weight, more preferably 3,000 or more of the weight-average molecular weight. The resin has usually 50,000 or less of the weight-average molecular weight, preferably more 30,000 or less of the weight-average molecular weight, and preferably more 15,000 or less of the weight-average molecular weight.

[0299] The weight-average molecular weight can be measured with gel permeation chromatography.

[0300] Examples of another resin than Resin (A) include what consists of structural units having no acid-labile group, preferably what comprises, not the structural unit (a1), but the structural unit having a fluorine atom such as the structural unit (a4). Here, such another resin is referred to as "Resin (X)".

[0301] Resin (X) may be one which consists of the structural unit having a fluorine atom, or one which further comprise the structural unit (a2), the structural unit (a3) or another structural unit having no acid-labile group, known in the art.

[0302] In Resin (X), the content of the structural unit (a4) is preferably 40% by mole or more, more preferably 45% by mole or more, still more preferably 50% by mole or more, and further more preferably 80% by mole or more, based on sum of the structural units in the resin.

[0303] Resin (X) usually has 8000 or more of the weight-average molecular weight, preferably 10000 or more of the weight-average molecular weight. The resin usually has 80,000 or less of the weight-average molecular weight, preferably has 60,000 or less of the weight-average molecular weight.

[0304] The weight-average molecular weight can be measured with known methods such as liquid chromatography or gas chromatography.

[0305] When the photoresist composition comprises Resin (X), the content of the resin is preferably 1 to 60 weight parts, more preferably 1 to 50 weight parts, and still more preferably 1 to 40 weight parts, and further still more preferably 2 to 30 weight parts, relative to 100 parts of Resin (A). Its content may be in the range of 7 to 30 weight parts relative to 100 parts of Resin (A).

[0306] The total content of the resins in the photoresist composition of the present invention is usually 80% by mass or more based on sum of solid component, and usually 99% by mass or less.

[0307] In this specification, "solid component" means components other than solvent in the photoresist composition.

<Acid Generator>

[0308] In the photoresist composition, an acid generates from the acid generator by exposure. The acid catalytically acts against an acid-labile group in the resin to cleave the acid-labile group.

[0309] The acid generator includes a nonionic acid generator, an ionic acid generator and the combination thereof. Examples of the nonionic acid generator include an organohalogen compound, a sulfonate compound such as a 2-nitrobenzylsulfonate, an aromatic sulfonate, an oxime sulfonate, an N-sulfonyloxymide, a sulfonyloxyketone and diazonaphthoquinone 4-sulfonate, and a sulfone compound such as a disulfone, a ketosulfone and a sulfonyldiazomethane. Examples of the ionic acid generator include an onium salt compound such as a diazonium salt, a phospho-

nium salt, a sulfonium salt and an iodonium salt. Examples of the anion of the onium salt include a sulfonic acid anion, a sulfonylimide anion and a sulfonylmethide anion.

[0310] Specific examples of the acid generator include acid generators described in JP 63-26653 A, JP 55-164824 A, JP62-69263 A, JP 63-146038 A, JP63-163452 A, JP62-153853 A, JP63-146029 A, U.S. Pat. No. 3,779,778, U.S. Pat. No. 3,849,137, DE Patent No. 3914407 and EP Patent No. 126,712.

[0311] The acid generator for the photoresist composition is preferably a fluorine-containing acid generator.

[0312] Preferable examples of the acid generator include a salt represented by the formula (B1):



wherein Q¹ and Q² each independently represent a fluorine atom or a C1-C6 perfluoroalkyl group,

[0313] L^{b1} represents a single bond or a C1-C24 divalent saturated hydrocarbon group in which a methylene group can be replaced by —O— or —CO— and in which a hydrogen atom can be replaced by a fluorine atom or a hydroxy group, and

[0314] Y represents a hydrogen atom or a C3-C18 alicyclic hydrocarbon group which can have a substituent and in which a methylene group can be replaced by —O—, —CO— or —SO₂—, and

[0315] Z⁺ represents an organic cation.

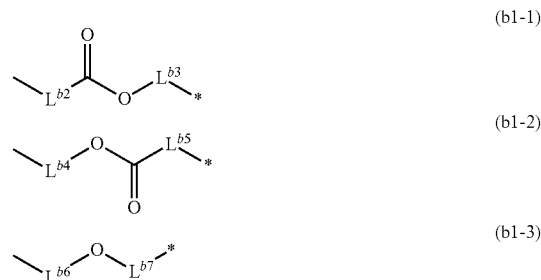
[0316] Examples of the perfluoroalkyl group include a trifluoromethyl group, a pentafluoroethyl group, a heptafluoropropyl group, a nonafluorobutyl group, an undecafluoropentyl group and a tridecafluorohexyl group, and a trifluoromethyl group is preferable. Q¹ and Q² each independently preferably represent a fluorine atom or a trifluoromethyl group, and Q¹ and Q² are more preferably fluorine atoms.

[0317] Examples of the divalent saturated hydrocarbon group represented by L^{b1} include an alkandiyl group, a monocyclic or polycyclic divalent saturated hydrocarbon group and a group formed by combining two or more groups selected from the group consisting of the alkandiyl group and the monocyclic or polycyclic divalent saturated hydrocarbon group.

[0318] Examples thereof include a linear alkanediyl group such as a methylene group, an ethylene group, a propane-1,3-diyl group, a butane-1,4-diyl group, a pentane-1,5-diyl, a hexane-1,6-diyl group, a heptane-1,7-diyl group, an octane-1,8-diyl group, a nonane-1,9-diyl group, a decane-1,10-diyl group, an undecane-1,11-diyl group, a dodecane-1,12-diyl group, a tridecane-1,13-diyl group, a tetradecane-1,14-diyl group, a pentadecane-1,15-diyl group, a hexadecane-1,16-diyl group and a heptadecane-1,17-diyl group, a branched chain alkanediyl group such as a butane-1,3-diyl group, a 2-methylpropane-1,3-diyl group, a 2-methylpropane-1,2-diyl group, a pentane-1,4-diyl group and a 2-methylbutane-1,4-diyl group, a monocyclic divalent saturated hydrocarbon group such as a cyclobutane-1,3-diyl group, a cyclopentane-1,3-diyl group, a cyclohexane-1,2-diyl group, a 1-methylcyclohexane-1,2-diyl group, a cyclohexane-1,4-diyl group, a cyclooctane-1,2-diyl group and a cyclooctane-1,5-diyl group, and a polycyclic divalent saturated hydrocarbon group

such as a norbornane-2,3-diyl group, a norbornane-1,4-diyl group, a norbornane-2,5-diyl group, an adamantane-1,2-diyl group, an adamantane-1,5-diyl group and an adamantane-2,6-diyl group.

[0319] Examples of the aliphatic hydrocarbon group in which a methylene group has been replaced by —O— or —CO— include those represented by formulae (b1-1), (b1-2) and (b1-3).



[0320] In formula (b1-1), L^{b2} represents a single bond or a C1-C22 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom, and L^{b3} represents a single bond or a C1-C22 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom and where a methylene group may be replaced by an oxygen atom or carbonyl group, provided that total number of the carbon atoms of L^{b2} and L^{b3} is up to 22.

[0321] In formula (b1-2), L^{b4} represents a C1-C22 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom, and L^{b5} represents a single bond or a C1-C22 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom and where a methylene group may be replaced by an oxygen atom or carbonyl group, provided that the total carbon atoms of L^{b4} and L^{b5} is up to 22.

[0322] In formula (b1-3), L^{b6} represents a single bond or a C1-C23 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom, and L^{b7} represents a single bond or a C1-C22 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom and where a methylene group may be replaced by an oxygen atom or carbonyl group, with the proviso that total carbon number of L^{b6} and L^{b7} is up to and with the proviso that formula (b1-3) excludes group having a structure represented by -L^{b8}-O—CO—.

[0323] In these formulae, * represents a binding position, * of the left side represents a binding position to —C(Q¹)(Q²)—, and * of the right side represents a binding position to the ring W¹.

[0324] In formulae (b1-1), (b1-2) and (b1-3), the divalent saturated hydrocarbon group includes linear chain alkanediyl groups, branched chain alkanediyl groups, monocyclic or polycyclic divalent saturated hydrocarbon groups, and a group combining two or more of the above-mentioned groups.

[0325] Specific examples of the divalent saturated hydrocarbon group include those as referred to for L^{b1}.

[0326] L^{b2} is preferably a single bond.

[0327] L^{b3} is preferably a C1-C4 alkanediyl group.

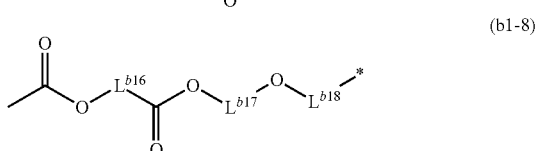
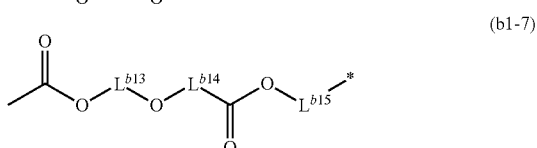
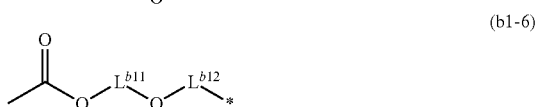
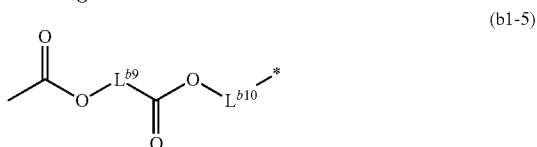
[0328] L^{b4} is preferably a C1-C8 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom.

[0329] L^{b8} is preferably a single bond or a C1-C8 divalent saturated hydrocarbon group.

[0330] L^{b6} is preferably a single bond or a C1-C4 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom.

[0331] L^{b7} is preferably a single bond or a C1-C7 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom and where a methylene group may be replaced by an oxygen atom or carbonyl group.

[0332] Among them, those of formulae (b1-1) and (b1-3) are preferred. Examples of the group represented by formula (b1-1) include those represented by formulae (b1-4), (b1-5), (b1-6), (b1-7) and (b1-8).



[0333] In formula (b1-4), L^{b8} represents a single bond or a C1-C22 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom or a hydroxyl group.

[0334] In formula (b1-5), L^{b9} represents a C1-C20 divalent saturated hydrocarbon group, and L^{b10} represents a single bond or a C1-C19 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom, provided that the total carbon atoms of L^{b10} and L^{b9} is up to 20.

[0335] In formula (b1-6), L^{b10} represents a C1-C21 divalent saturated hydrocarbon group, and L^{b10} represents a single bond or a C1-C20 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom, with the proviso that total carbon number of L^{b11} and L^{b12} is up to 21.

[0336] In formula (b1-7), L^{b13} represents a C1-C19 divalent saturated hydrocarbon group, L^{b14} represents a single bond or a C1-C18 divalent saturated hydrocarbon group, and L^{b15} represents a single bond or a C1-C18 divalent saturated hydrocarbon group where a hydrogen atom may be replaced

by a hydroxyl group or a fluorine atom, with the proviso that total carbon number of L^{b13} , L^{b14} and L^{b15} is up to 19.

[0337] In formula (b1-8), L^{b16} represents a C1-C18 divalent saturated hydrocarbon group, L^{b17} represents a C1-C18 divalent saturated hydrocarbon group, and L^{b18} represents a single bond or a C1-C17 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom, with the proviso that total carbon number of L^{b16} , L^{b17} and L^{b18} is up to 19.

[0338] In these formulae, * represents a binding position, * of the left side represents a binding position to $-C(Q^1)(Q^2)-$, and * of the right side represents a binding position to the ring W^1 .

[0339] In these formulae, the divalent saturated hydrocarbon group includes linear chain alkanediyl groups, branched chain alkanediyl groups, monocyclic or polycyclic divalent saturated hydrocarbon groups, and a group combining two or more of the above-mentioned groups. Specific examples of the divalent saturated hydrocarbon group include those as referred to for L^{b1} .

[0340] L^{b8} is preferably a C1-C4 alkanediyl group.

[0341] L^{b9} is preferably a C1-C8 divalent saturated hydrocarbon group.

[0342] L^{b10} is preferably a single bond or a C1-C19 divalent saturated hydrocarbon group, and more preferably a single bond or a C1-C8 divalent saturated hydrocarbon group.

[0343] L^{b11} is preferably a C1-C8 divalent saturated hydrocarbon group.

[0344] L^{b12} is preferably a single bond or a C1-CB divalent saturated hydrocarbon group.

[0345] L^{b13} is preferably a C1-C12 divalent saturated hydrocarbon group.

[0346] L^{b14} is preferably a single bond or a C1-C6 divalent saturated hydrocarbon group.

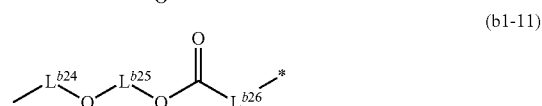
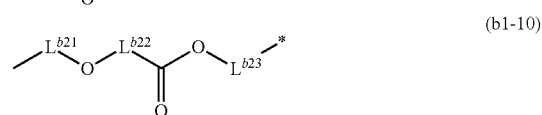
[0347] L^{b15} is preferably a single bond or a C1-C18 divalent saturated hydrocarbon group, and more preferably a single bond or a C1-C8 divalent saturated hydrocarbon group.

[0348] L^{b16} is preferably a C1-C12 divalent saturated hydrocarbon group.

[0349] L^{b17} is preferably a C1-C6 divalent saturated hydrocarbon group.

[0350] L^{b18} is preferably a single bond or a C1-C17 divalent saturated hydrocarbon group, and more preferably a single bond or a C1-C4 divalent saturated hydrocarbon group.

[0351] Examples of the group represented by formula (b1-3) include those represented by formulae (b1-9), (b1-10) and (b1-11).



[0352] In formula (b1-9), L^{b19} represents a single bond or a C1-C23 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom, and L^{b20}

represents a single bond or a C1-C23 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom and where a methylene group may be replaced by an oxygen atom or carbonyl group, provided that the total carbon atoms of L^{b19} and L^{b20} is up to 23. In formula (b1-10), L^{b21} represents a single bond or a C1-C21 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom, L^{b22} represents a single bond or a C1-C21 divalent saturated hydrocarbon group and L^{b23} represents a single bond or a C1-C21 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom and where a methylene group may be replaced by an oxygen atom or a carbonyl group, provided that the total carbon atoms of L^{b21} , L^{b22} and L^{b23} is up to 21.

[0353] In formula (b1-11), L^{b24} represents a single bond or a C1-C21 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a fluorine atom, L^{b25} represents a single bond or a C1-C21 divalent saturated hydrocarbon group, and L^{b26} represents a single bond or a C1-C20 divalent saturated hydrocarbon group where a hydrogen atom may be replaced by a hydroxyl group or a fluorine atom and where a methylene group may be replaced by an oxygen atom or a carbonyl group, provided that the total carbon atoms of L^{b24} , L^{b25} and L^{b26} is up to 21.

[0354] In these formulae, * represents a binding position, * represents a binding position to Y.

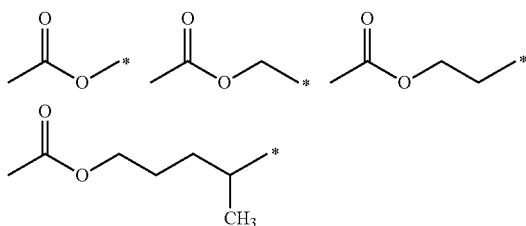
[0355] In these formulae, the divalent saturated hydrocarbon group includes linear chain alkanediyl groups, branched chain alkanediyl groups, monocyclic or polycyclic divalent saturated hydrocarbon groups, and a group combining two or more of the above-mentioned groups. Specific examples of the divalent saturated hydrocarbon group include those as referred to for L^{b1} .

[0356] Examples of the divalent saturated hydrocarbon group where a methylene group has been replaced by an oxygen atom or a carbonyl group include those having an acyloxy group where a hydrogen atom may be replaced by a hydroxyl group and where a methylene group may be replaced by an oxygen atom or a carbonyl group.

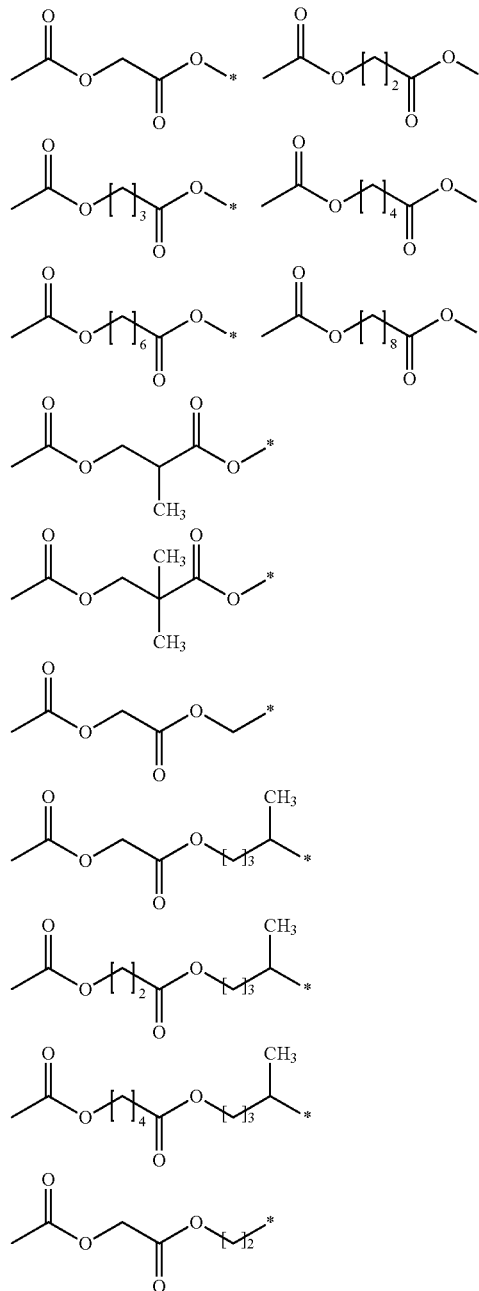
[0357] Examples of acyloxy group include an acetyloxy group, a propionyloxy group, a butyryloxy group, a cyclohexylcarbonyloxy group and an adamantylcarbonyloxy group.

[0358] Examples of acyloxy group where a hydrogen atom has been replaced by a hydroxyl group or where a methylene group has been replaced by an oxygen atom or a carbonyl group include an oxoadamantylcarbonyloxy group, a hydroxyadamantylcarbonyloxy group, an oxocyclohexylcarbonyloxy group, and a hydroxycyclohexylcarbonyloxy group.

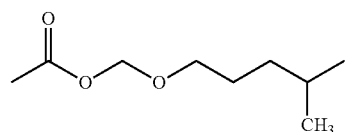
[0359] Examples of the group represented by formula (b1-4) include the following ones.



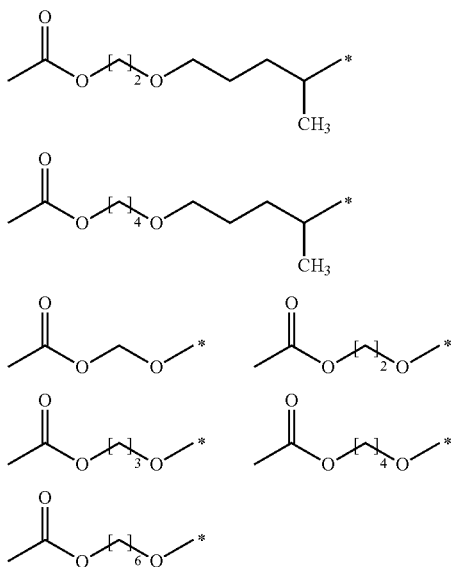
[0360] Examples of the group represented by formula (b1-5) include the following ones.



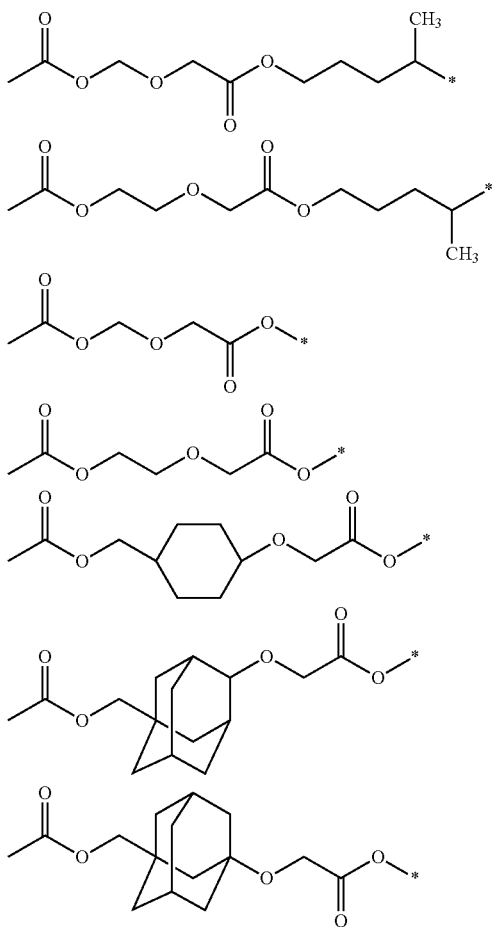
[0361] Examples of the group represented by formula (b1-8) include the following ones.



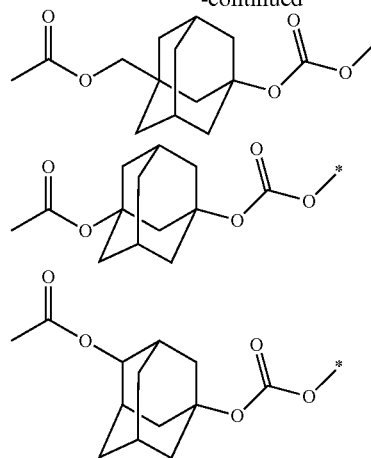
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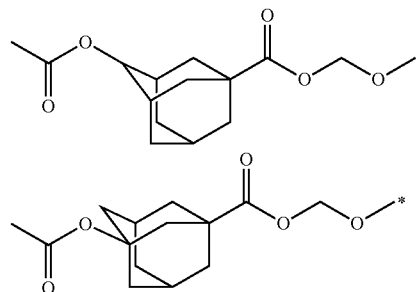
[0362] Examples of the group represented by formula (b1-7) include the following ones.



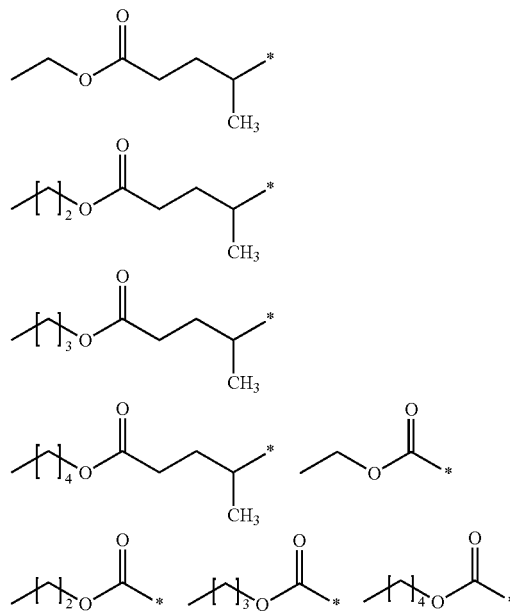
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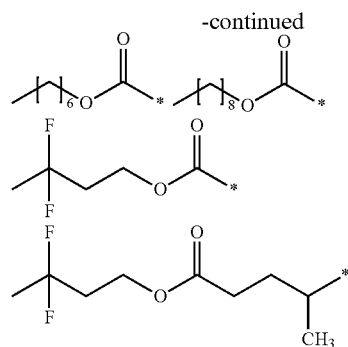


[0363] Examples of the group represented by formula (b1-8) include the following ones.

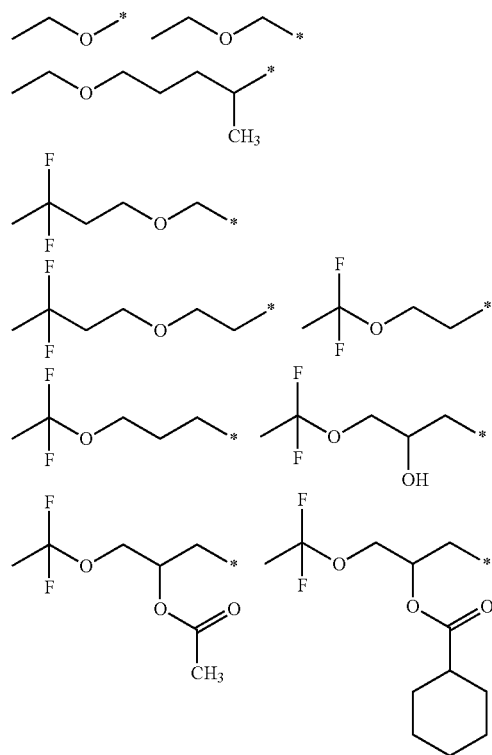


[0364] Examples of the group represented by formula (b1-2) include the following ones.

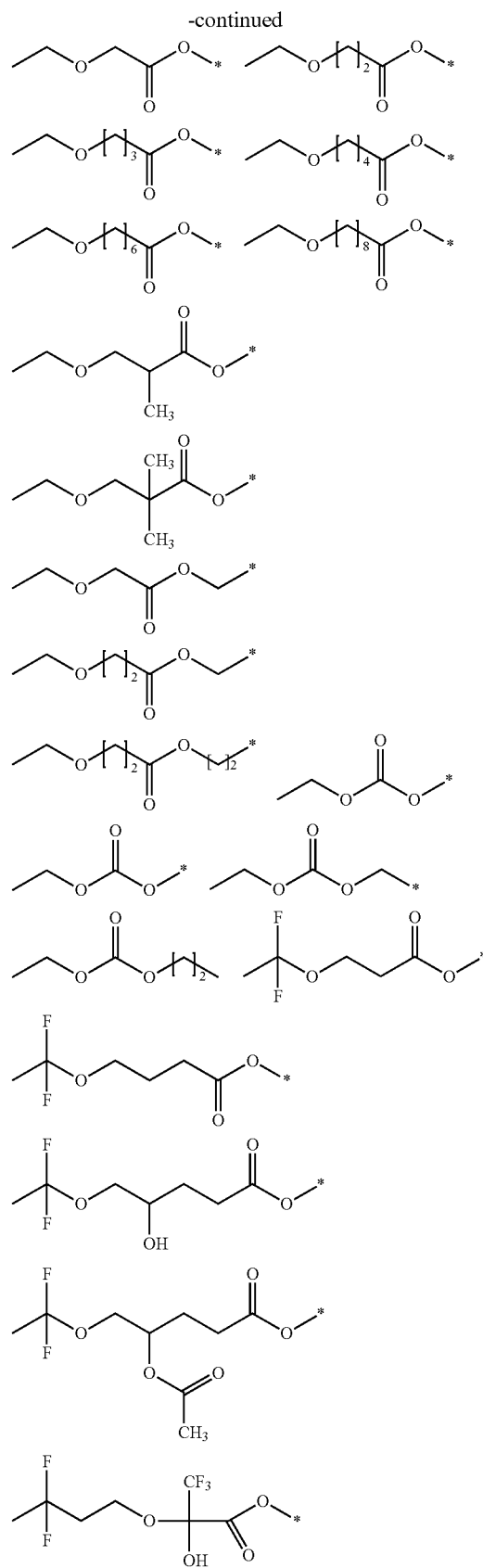
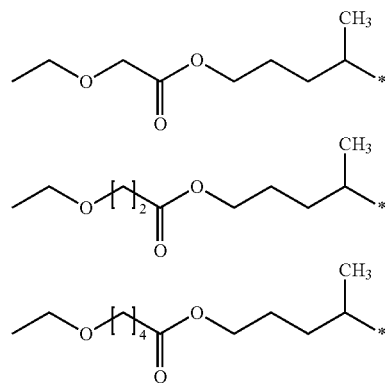


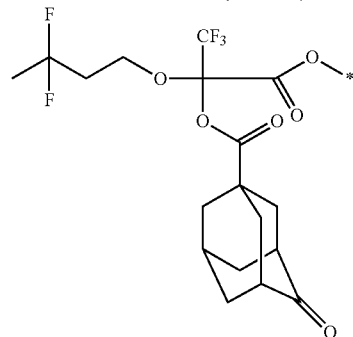
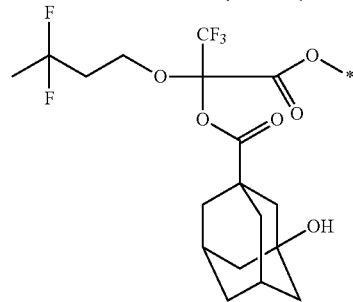
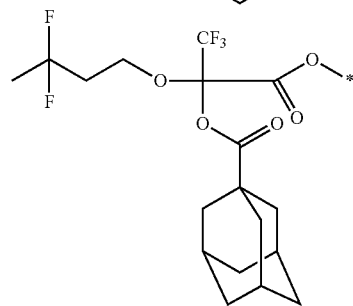
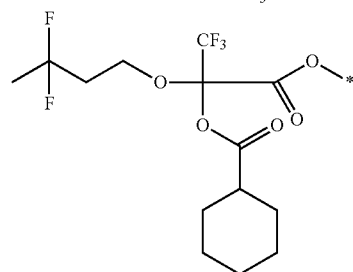
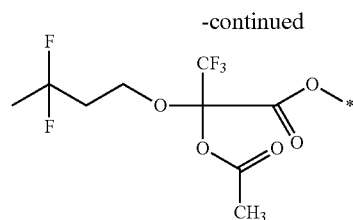


[0365] Examples of the group represented by formula (b1-9) include the following ones.

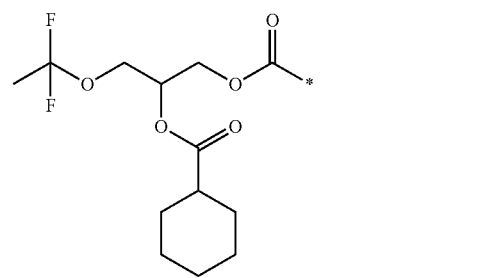
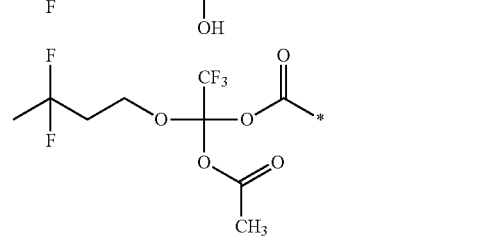
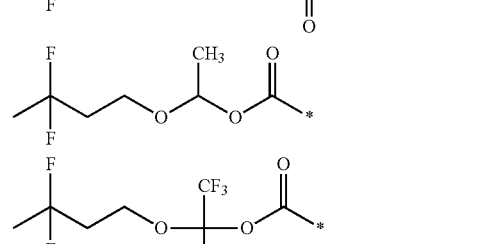
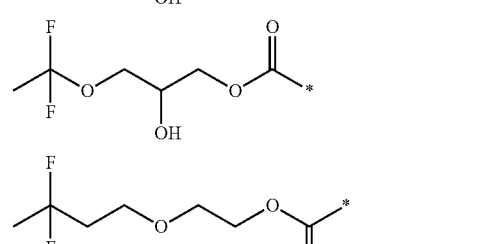
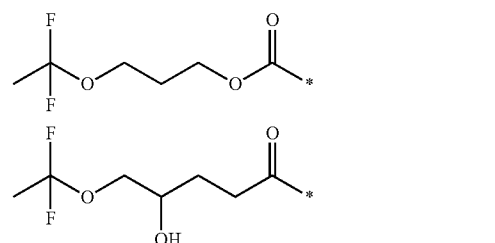
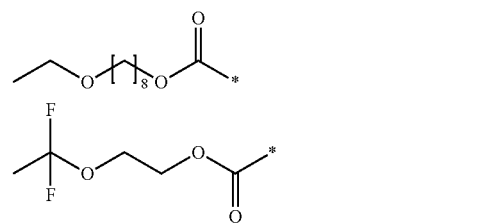
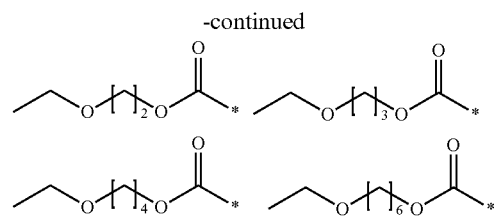
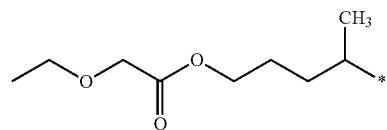


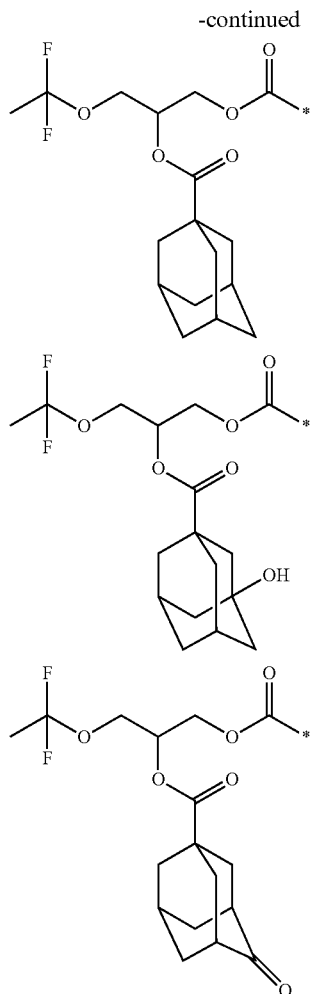
[0366] Examples of the group represented by formula (b1-10) include the following ones.





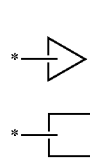
[0367] Examples of the group represented by formula (b1-11) include the following ones.





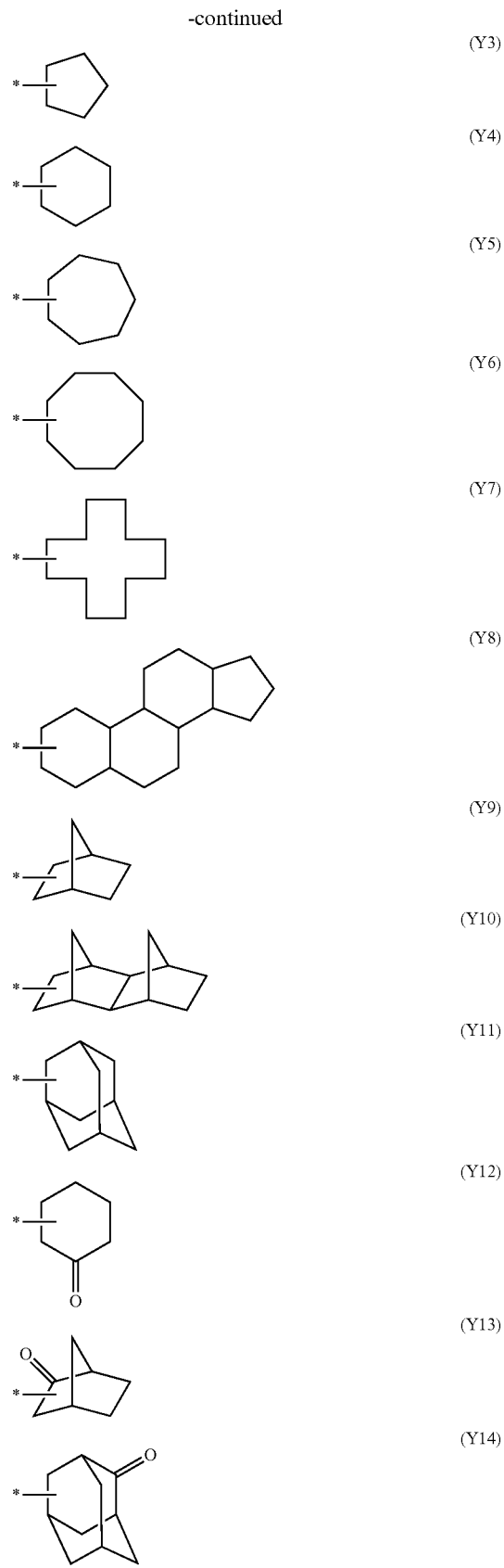
[0368] Preferred examples of the alicyclic hydrocarbon group represented by Y include those represented by the formula (Y1), the formula (Y2), the formula (Y3), the formula (Y4), the formula (Y5), the formula (Y6), the formula (Y7), the formula (Y8), the formula (Y9), the formula (Y10) and the formula (Y11).

[0369] When a methylene group has been replaced by an oxygen atom, a sulfonyl group or a carbonyl group in the alicyclic hydrocarbon group represented by Y, preferred examples of Y include those represented by the formula (Y12), the formula (Y13), the formula (Y14), the formula (Y15), the formula (Y16), the formula (Y17), the formula (Y18), the formula (Y19), the formula (Y20), the formula (Y21), the formula (Y22), the formula (Y23), the formula (Y24), the formula (Y25) and the formula (Y26).

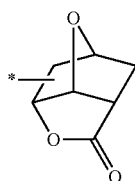
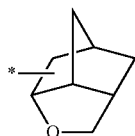
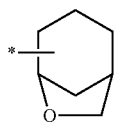
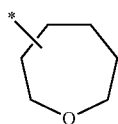
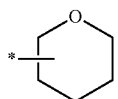
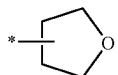
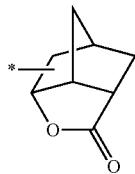
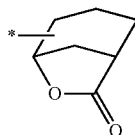
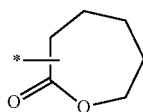
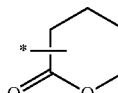
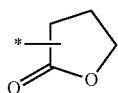


(Y1)

(Y2)



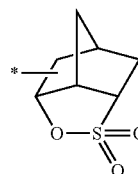
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(Y26)

(Y15)



(Y16)

(Y17)

(Y18)

(Y19)

(Y20)

(Y21)

(Y22)

(Y23)

(Y24)

(Y25)

[0370] Among the groups represented by the formula (Y1) to the formula (Y26), preferred are those represented by formulae (Y1) to (Y19); more preferred are those represented by the formulae (Y11), (Y14), (Y15) and (Y19); and still more preferred are those represented by the formulae (Y11) and (Y14).

[0371] Substituents of the alicyclic hydrocarbon groups represented by Y include a halogen atom, an C1-C12 alkyl group, a hydroxyl group, a C1-C12 alkoxy group, a C3-C16 alicyclic hydrocarbon group, a C6-C18 aromatic hydrocarbon group, a C7-C21 aralkyl group, a C2-C4 acyl group, a glycidyloxy group, and $-(CH_2)_j-O-CO-R^{b1}-$ in which R^{b1} and j_2 are defined as above. Each of the alkyl group, the alicyclic hydrocarbon group, the aromatic hydrocarbon group and the aralkyl group, which is the substituent for the alicyclic hydrocarbon groups represented by Y may have a substituent such as an alkyl group, a halogen atom or a hydroxyl group.

[0372] Examples of hydroxyl-containing alkyl group include a hydroxymethyl group and a hydroxyethyl group.

[0373] Examples of the C1-C12 alkoxy group include a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentyloxy group, a hexyloxy group, a heptyloxy group, an octyloxy group, a decyloxy group and a dodecyloxy group.

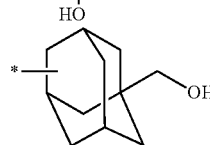
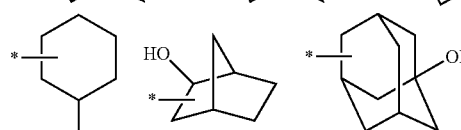
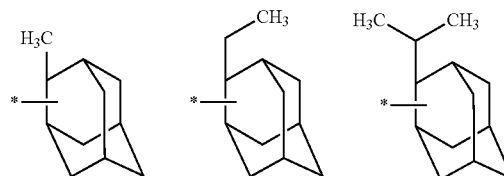
[0374] Examples of the aromatic hydrocarbon group include an aryl group such as a phenyl group, a naphthyl group, an anthryl group, a p-methylphenyl group, a p-tert-butylphenyl group, a p-adamantylphenyl group, a tolyl group, a xylyl group, a cumyl group, a mesityl group, a biphenyl group, a phenanthryl group, a 2,6-diethylphenyl group and a 2-methyl-6-ethylphenyl group.

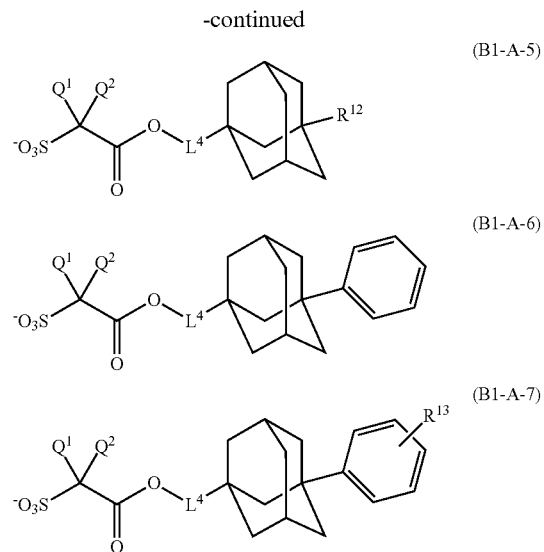
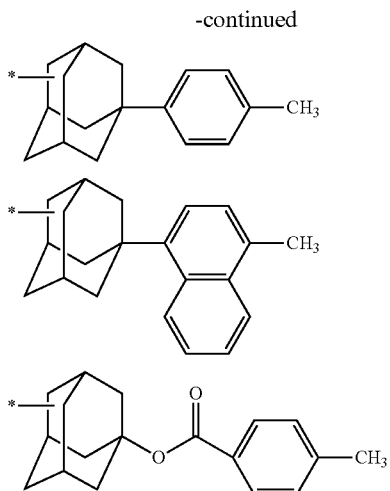
[0375] Examples of the aralkyl group include a benzyl group, phenylpropyl group, a phenethyl group, a naphthylmethyl group, or a naphthylethyl group.

[0376] Examples of the acyl group include an acetyl group, a propionyl group and a butyryl group.

[0377] Examples of the halogen atom include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

[0378] Examples of Y include the groups as follow.

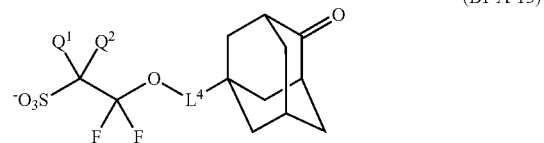
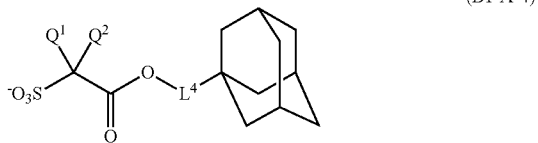
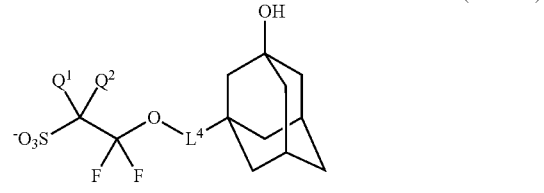
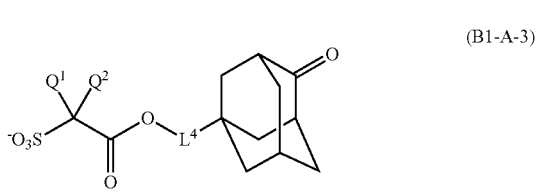
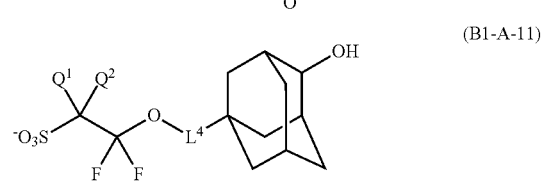
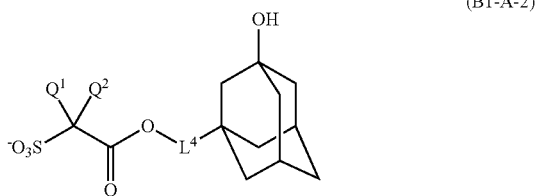
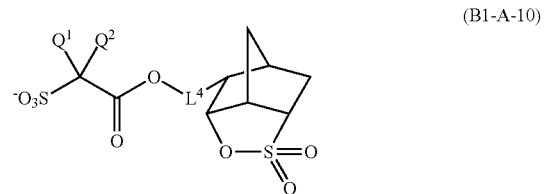
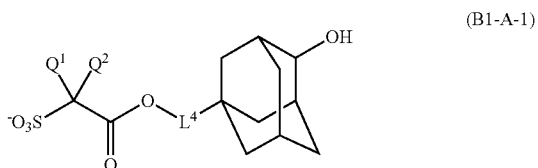




where * represents a binding position.

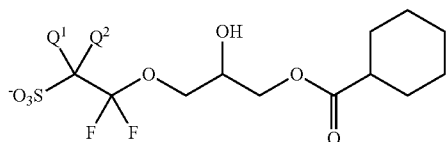
[0379] Y represents preferably a C3-C18 alicyclic hydrocarbon group which may have a substituent, more preferably an amadantyl group which may have a substituent, and still more preferably an amadantyl group, a hydroxyamadantyl group or an oxoamadantyl group.

[0380] Preferred examples of the sulfonic acid anion of the salt represented by formula (B1) include salts represented by the formulae (B1-A-1) to (B1-A-33), preferably the formulae (B1-A-1) to (B1-A-4), (B1-A-9), (B1-A-10) and (B1-A-24) to (B1-A-33).

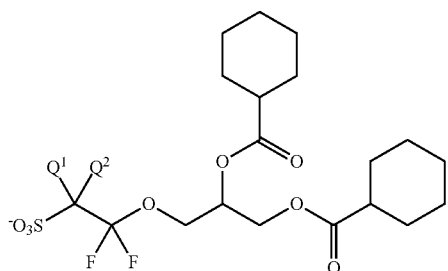


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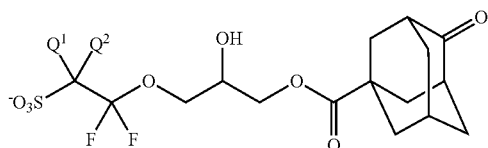
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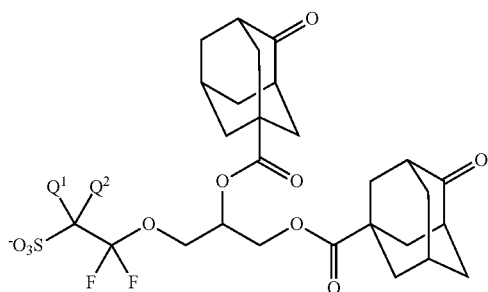
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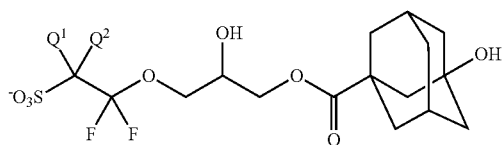
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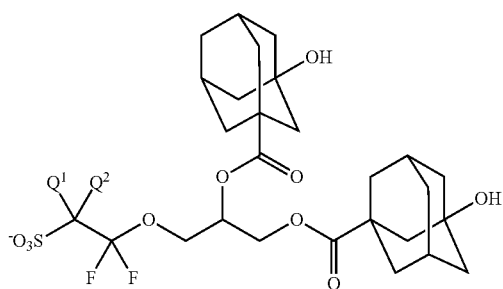
(B1-A-17)



(B1-A-18)

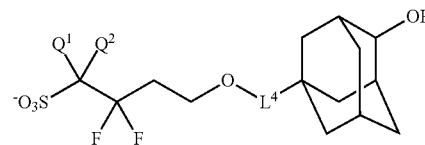


(B1-A-19)

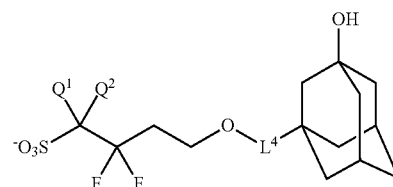


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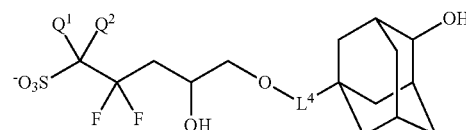
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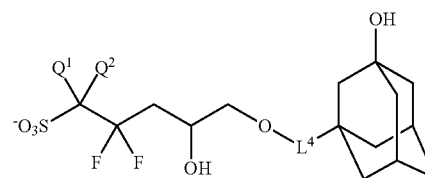
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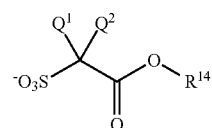
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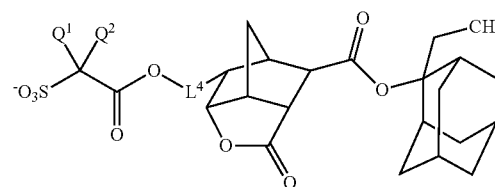
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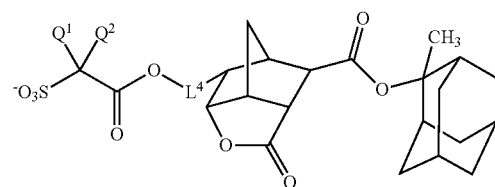
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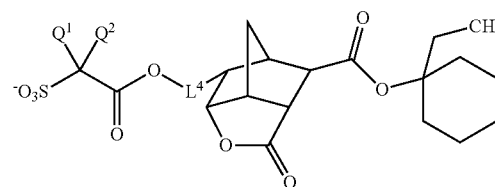
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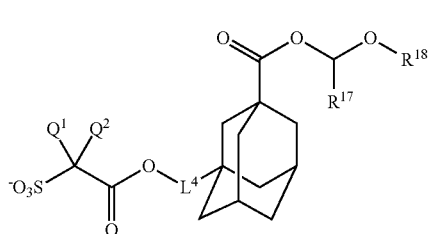
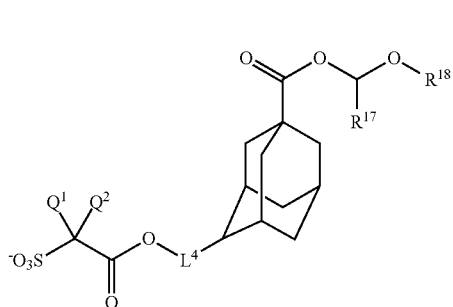
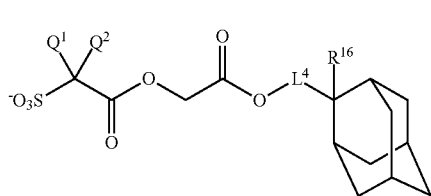
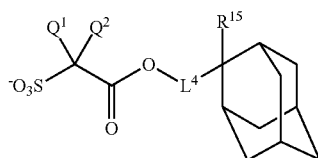
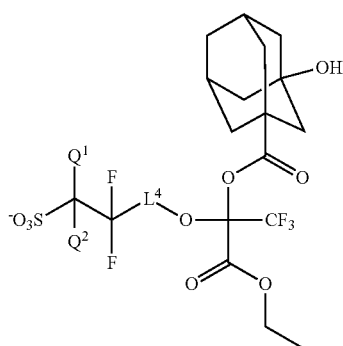
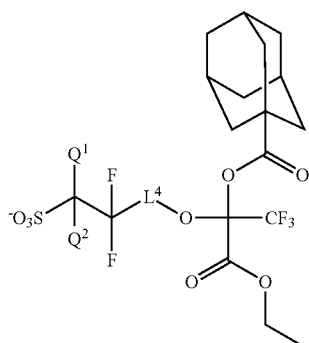
(B1-A-26)



(B1-A-27)



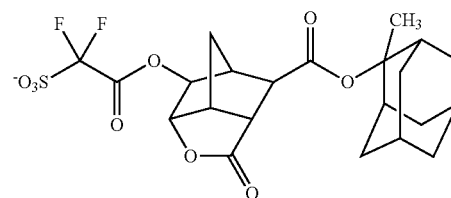
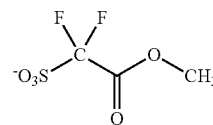
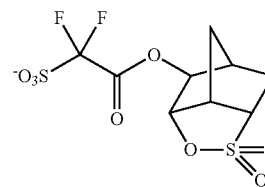
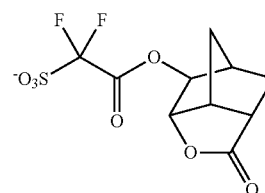
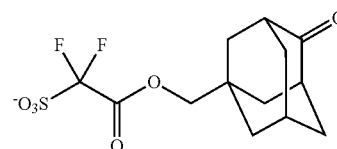
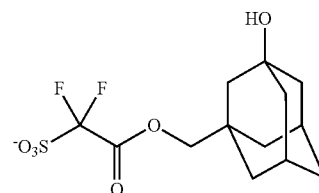
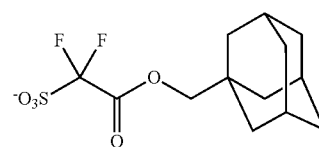
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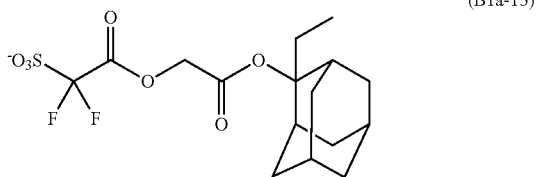
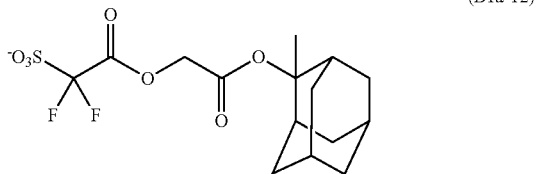
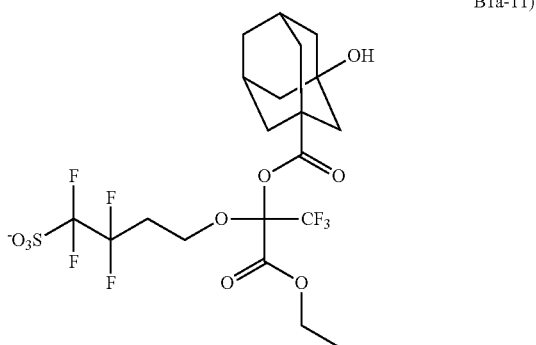
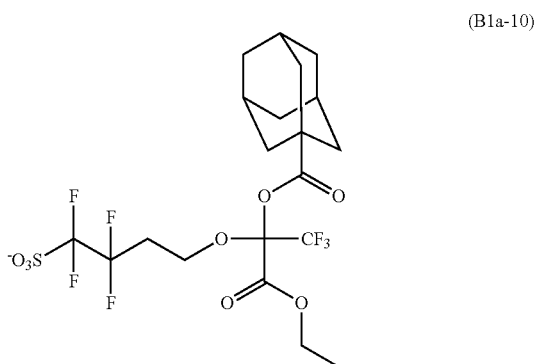
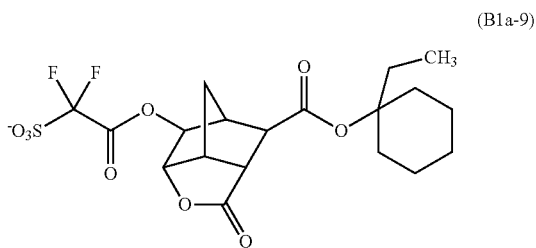
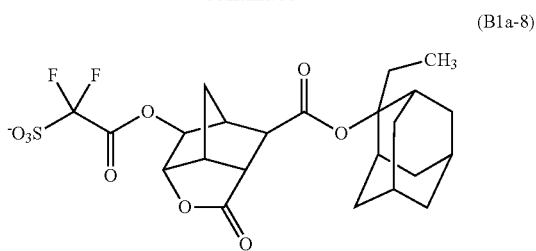
[0381] In these formulae, the symbols Q^1 , Q^2 , L^4 , Y and Z^+ are defined as above, R^{12} , R^{13} , R^{14} , R^{15} , R^{16} and R^{17} each independently represent a C1-C4 alkyl group, preferably a methyl group or an ethyl group, R^{18} represents a C1-C12 aliphatic hydrocarbon group [preferably a C1-C4 alkyl group], a C5-C12 monovalent alicyclic hydrocarbon group, or a combined group of them, preferably a methyl group, an ethyl group, a cyclohexyl group or an adamantyl group, and L^4 represents a single bond or a C1-C4 alkanediyl group.

[0382] Specific examples of the sulfonic acid anion of the salt represented by formula (B1) include anions mentioned in JP2010-204646A1.

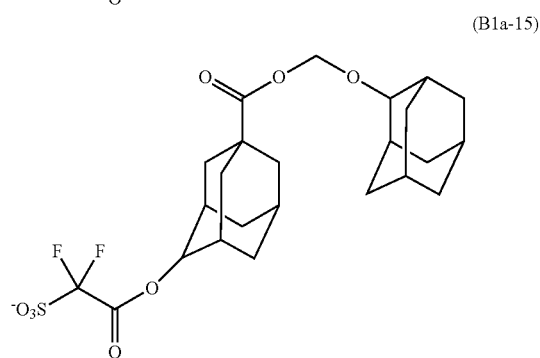
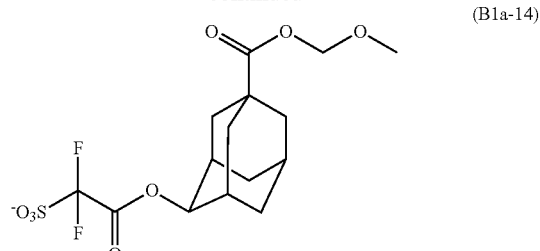
[0383] Among them, preferred examples of the sulfonic acid anion for the salt represented by formula (B1) include anions represented by formulae (B1a-1) to (B1a-15).



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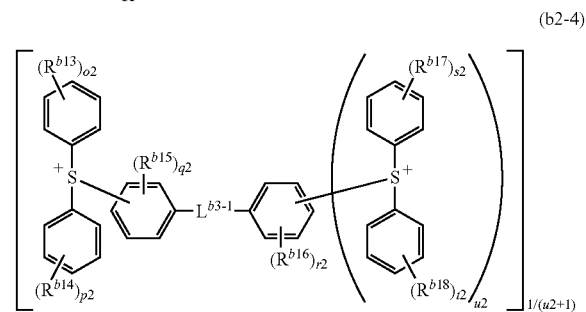
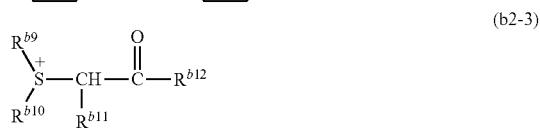
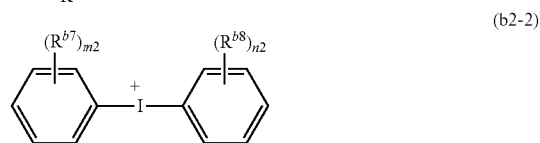
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[0384] Among them, preferred are those represented by formulae (B1a-1) to (B1a-3) and (B1a-7) to (B1a-15).

[0385] Examples of the organic counter ion represented by Z* include an onium cation such as a sulfonium cation, an iodonium cation, an ammonium cation, a benzothiazolium cation and a phosphonium cation, and a sulfonium cation and an iodonium cation are preferred, and a sulfonium cation, specifically arylsulfonium cation, is more preferred.

[0386] Preferred examples of the organic cation include the organic cations represented by the formulae (b2-1), (b2-2), (b2-3) and (b2-4):



[0387] In the formulae (b2-1) to (b2-4) R^{b4} , R^{b5} and R^{b6} independently represent a C1-C30 aliphatic hydrocarbon group, a C3-C36 alicyclic hydrocarbon group and a C6-C36 aromatic hydrocarbon group. The aliphatic hydrocarbon group can have a substituent selected from the group consisting of a hydroxy group, a C1-C12 alkoxy group, a C3-C12 alicyclic hydrocarbon group and a C6-C18 aromatic hydrocarbon group. The alicyclic hydrocarbon group can have a substituent selected from the group consisting of a halogen atom, a C1-C18 aliphatic hydrocarbon group, a C2-C4 acyl group and a glycidyloxy group. The aromatic hydrocarbon group can have a substituent selected from the group consisting of a halogen atom, a hydroxy group, a C1-C18 aliphatic hydrocarbon group and a C1-C12 alkoxy group.

[0388] R^{b4} and R^{b5} can be bonded to form a ring together with the adjacent S⁺, and a methylene group in the ring may be replaced by —CO—, —O— or —SO—.

[0389] R^{b7} and R^{b8} are independently in each occurrence a hydroxy group, a C1-C12 alkyl group or a C1-C12 alkoxy group, m2 and n2 independently represents an integer of 0 to 5.

[0390] R^{b9} and R^{b10} independently represent a C1-C36 aliphatic hydrocarbon group or a C3-C36 alicyclic hydrocarbon group.

[0391] R^{b9} and R^{b10} can be bonded to form a ring together with the adjacent S⁺, and a methylene group in the divalent acyclic hydrocarbon group may be replaced by —CO—, —O— or —SO—.

[0392] R^{b11} represents a hydrogen atom, a C1-C36 aliphatic hydrocarbon group, a C3-C36 alicyclic hydrocarbon group or a C6-C18 aromatic hydrocarbon group.

[0393] R^{b12} represents a C1-C12 aliphatic hydrocarbon group in which a hydrogen atom can be replaced by a C6-C18 aromatic hydrocarbon group, a C3-C18 saturated cyclic hydrocarbon group and a C6-C18 aromatic hydrocarbon group in which a hydrogen atom can be replaced by a C1-C12 alkoxy group or a (C1-C12 alkyl)carbonyloxy group.

[0394] R^{b11} and R^{b12} can be bonded each other to form a C1-C10 divalent acyclic hydrocarbon group which forms a 2-oxocycloalkyl group together with the adjacent —CHCO—, and a methylene group in the divalent acyclic hydrocarbon group may be replaced by —CO—, —O— or —SO—.

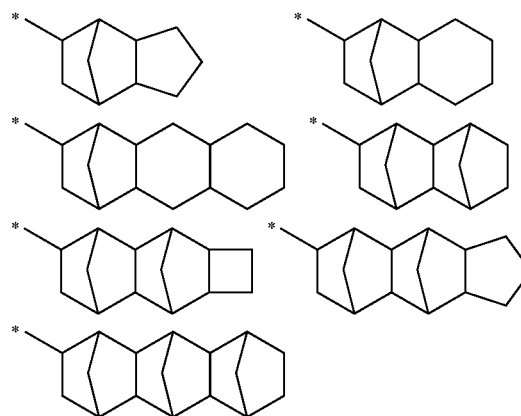
[0395] R^{b13} , R^{b14} , R^{b15} , R^{b16} , R^{b17} and R^{b18} independently represent a hydroxy group, a C1-C12 aliphatic hydrocarbon group or a C1-C12 alkoxy group.

[0396] L^{b31} represents —S— or —O— and o2, p2, s2 and t2 each independently represents an integer of 0 to 5, q2 and r2 each independently represents an integer of 0 to 4, and u2 represents 0 or 1.

[0397] Preferred examples of the aliphatic hydrocarbon group represented by R^{b4} to R^{b12} include an alkyl group such as a methyl group, an ethyl group, a propyl group, an isopropyl group, 2,2-dimethylethyl group, 1-methylpropyl group, a 2-methylpropyl group, a 1,2-dimethylpropyl group, a 2,2-dimethylpropyl group, a 1-ethylpropyl group, a butyl group, a sec-butyl group, a tert-butyl group, a pentyl group, a 1-methylbutyl group, a 2-methylbutyl group, a 3-methylbutyl group, a hexyl group, a 1-propylbutyl group, a 1-methylpentyl group, a 2-ethylhexyl group, a 1,4-dimethylhexyl group, a 1-methylheptyl group, an octyl group, a decyl group, a dodecyl group, a hexadecyl group, a pentadecyl group, a heptadecyl group and an octadecyl group, and more preferred examples thereof include a methyl group, an ethyl group, a

propyl group, an isopropyl group, a butyl group, a sec-butyl group, a tert-butyl group, a pentyl group, a hexyl group, an octyl group and a 2-ethylhexyl group. The aliphatic hydrocarbon group represented by R^{b9} , R^{b10} , R^{b11} and R^{b12} has preferably 1 to 12 carbon atoms, more preferably 4 to 12 carbon atoms.

[0398] The alicyclic hydrocarbon group may be monocyclic or polycyclic. Preferred examples thereof include a cycloalkyl group such as a cyclopentyl group, a cyclohexyl group, a methylcyclohexyl group, a dimethylcyclohexyl group, a cycloheptyl group and a cyclooctyl group, a group obtained by hydrogenating a condensed aromatic hydrocarbon group such as a hydronaphthyl group, a bridged cyclic hydrocarbon group such as an adamantyl group, a norbornyl group and a decahydronaphthyl group, and the following groups.



[0399] The alicyclic hydrocarbon group represented by R^{b9} , R^{b10} , R^{b11} and R^{b12} has preferably 3 to 18 carbon atoms, more preferably 4 to 12 carbon atoms.

[0400] Examples of the alicyclic hydrocarbon group in which a hydrogen atom has been replaced by an aliphatic hydrocarbon group include a methylcyclohexyl group, a dimethylcyclohexyl group, a methylnorbornyl group, and an isonorbornyl group.

[0401] The alicyclic hydrocarbon group in which a hydrogen atom has been replaced by an aliphatic hydrocarbon group has preferably or less carbon atoms in total.

[0402] Examples of the aromatic hydrocarbon group include an aryl group such as a phenyl group, tolyl group, xyllyl group, cumenyl group, mesityl group, p-ethylphenyl group, p-tert-butylphenyl group, p-adamantylphenyl group, a biphenyl group, a naphthyl group, a phenanthryl group, a 2,6-diethylphenyl group, a 2-methyl-6-ethylphenyl group.

[0403] When the aromatic hydrocarbon group has an alicyclic hydrocarbon group or an aliphatic hydrocarbon group, it is preferred that the alicyclic hydrocarbon group and the aliphatic hydrocarbon group have respectively 1 to 18 carbon atoms and 3 to 18 carbon atoms.

[0404] Examples of the aromatic hydrocarbon group in which a hydrogen atom has been replaced by an alkoxy group include p-methoxyphenyl group.

[0405] Examples of the aliphatic hydrocarbon group in which a hydrogen atom has been replaced by an aromatic hydrocarbon group include a benzyl group, a phenethyl

group, a phenylpropyl group, trityl group, naphthylmethyl group, and a naphthylethyl group.

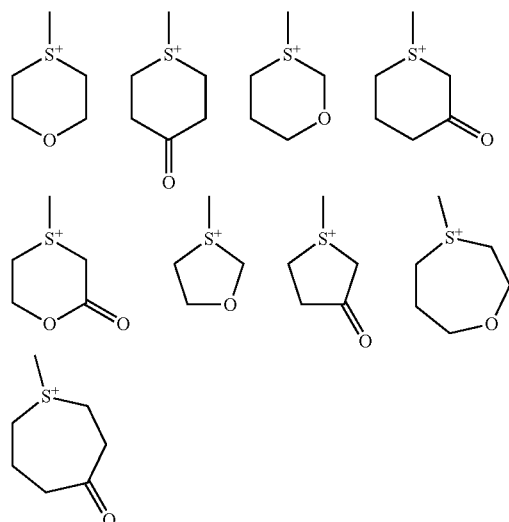
[0406] Examples of the alkoxy group include a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a pentyloxy group, a hexyloxy group, a heptyloxy group, an octyloxy group, a decyloxy group and a dodecyloxy group.

[0407] Examples of the acyl group include an acetyl group, a propionyl group and a butyryl group.

[0408] Examples of the halogen atom include a fluorine atom, a chlorine atom, a bromine atom and an iodine atom.

[0409] Examples of alkylcarbonyloxy group include a methylcarbonyloxy group, an ethylcarbonyloxy group, a n-propylcarbonyloxy group, an isopropylcarbonyloxy group, a n-butylcarbonyloxy group, a sec-butylcarbonyloxy group, a tert-butylcarbonyloxy group, a pentylcarbonyloxy group, a hexylcarbonyloxy group, an octylcarbonyloxy group and a 2-ethyl hexylcarbonyloxy group.

[0410] The ring group formed by bonding R^{b4} and R^{b5} together with the adjacent S^+ may be monocyclic or polycyclic, saturated or unsaturated, aromatic or nonaromatic group. The ring is generally 3 to 12-membered one, preferably 3 to 7-membered one. Examples of the ring include the following ones.

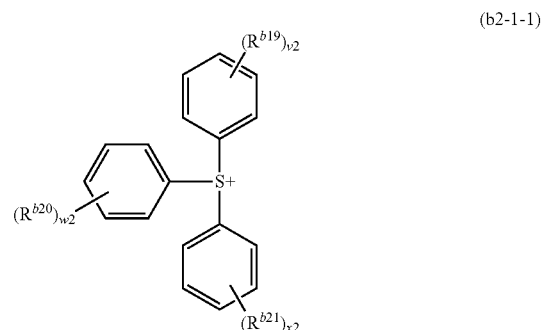


[0411] The ring group formed by bonding R^{b9} and R^{b10} together with the adjacent S^+ may be monocyclic or polycyclic, saturated or unsaturated, aromatic or nonaromatic group. The ring has generally C3-C12, preferably C3-C7 carbon atoms. Examples of the ring include a thiolan-1-ium ring (tetrahydrothiophenium ring), a thian-1-ium ring and a 1,4-oxathian-4-ium ring.

[0412] The ring group formed by bonding R^{b11} and R^{b12} together with $—CH—CO—$ may be monocyclic or polycyclic, saturated or unsaturated, aromatic or nonaromatic group. The ring has generally C3-C12, preferably C3-C7 carbon atoms. Examples of the ring include an oxocycloheptane ring, an oxocyclohexane ring, an oxonorborene ring, and an oxiadamantane ring.

[0413] Preferred examples of the cation for the acid generator include an arylsulfonium cation, specifically cation of formula (b2-1), and more specifically a phenylsulfonium cation.

[0414] The cation of formula (b2-1) is preferably represented by formula (b2-1-1).



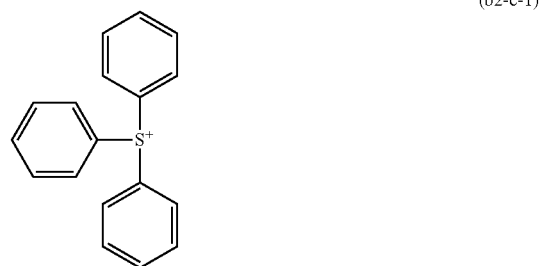
wherein R^{b19} , R^{b20} and R^{b21} are independently in each occurrence a halogen atom (preferably a fluorine atom), a hydroxyl group, a C1-C18 aliphatic hydrocarbon group, C3-C18 alicyclic hydrocarbon group or a C1-C12 alkoxy group, and $v2$, $w2$ and $x2$ independently each represent an integer of 0 to 5.

[0415] The aliphatic hydrocarbon group has preferably 1 to 12 carbon atoms, and a C1-C12 alkyl group is preferred. The $v2$, $w2$ and $x2$ independently each preferably represent 0 or 1.

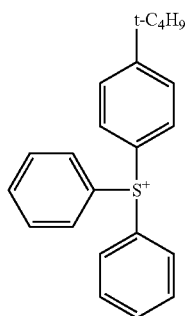
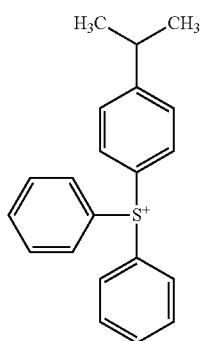
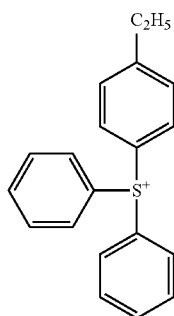
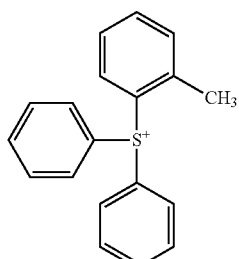
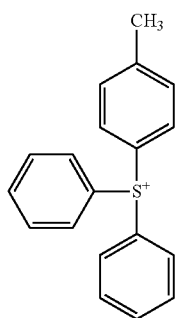
[0416] Preferably, R^{b19} , R^{b20} and R^{b21} are independently in each occurrence a halogen atom, a hydroxyl group, a C1-C12 alkyl group or a C1-C12 alkoxy group, and $v2$, $w2$ and $x2$ independently each represent an integer of 0 to 5. More preferably, R^{b19} , R^{b20} and R^{b21} are independently in each occurrence a fluorine atom, a hydroxyl group, a C1-C12 alkyl group or a C1-C12 alkoxy group, and $v2$, $w2$ and $x2$ independently each represent 0 or 1.

[0417] Specific examples of formula (b2-1-1) include those recited in JP2010-204646A1, specifically a triphenylsulfonium cation which is represented by formula (b1-1-1) where each of $v2$, $w2$ and $x2$ is 0, a diphenyltolylsulfonium cation which is represented by formula (b1-1-1) where $v2$ and $w2$ are 0, $x2$ is 1, and R^{b21} is a methyl group, and a tritolylsulfonium cation which is represented by formula (b1-1-1) where $v2$, $w2$ and $x2$ are 0, and R^{b19} , R^{b20} and R^{b21} are a methyl group.

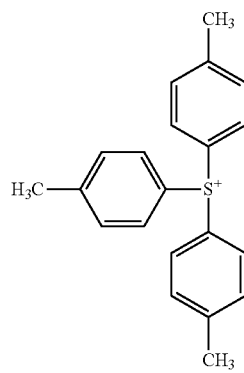
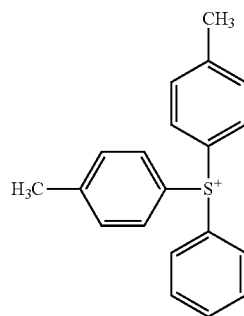
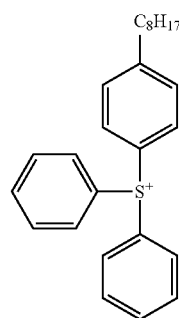
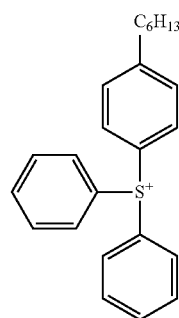
[0418] Examples of the cation represented by the formula (b2-1) include the followings.



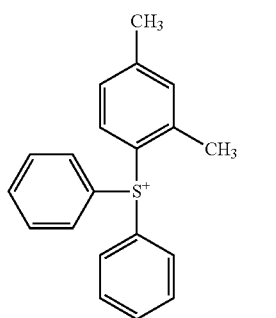
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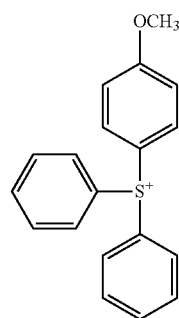


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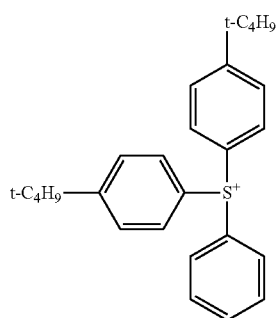
(b2-c-11)

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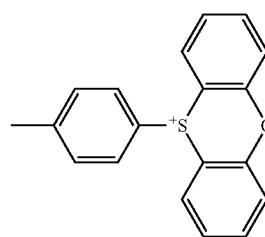


(b2-c-16)

(b2-c-12)

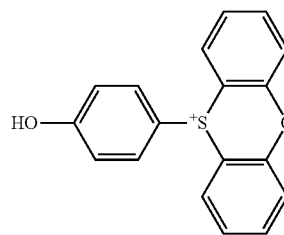
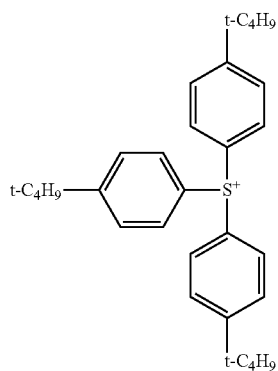


(b2-c-17)



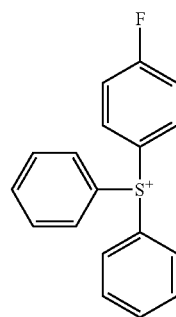
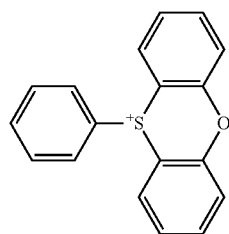
(b2-c-18)

(b2-c-13)



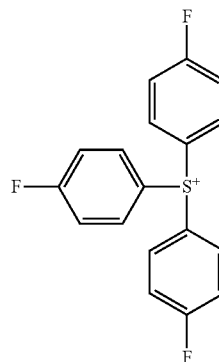
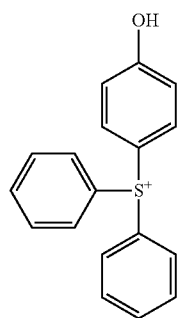
(b2-c-19)

(b2-c-14)

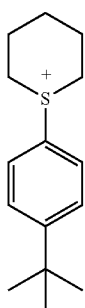
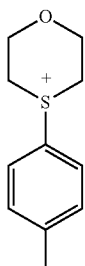
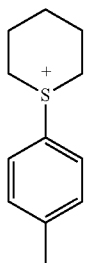
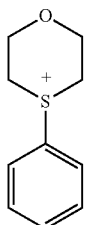
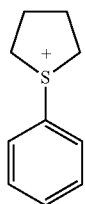
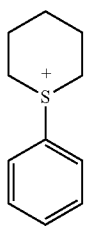


(b2-c-20)

(b2-c-15)

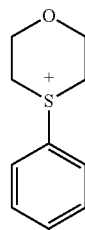


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(b2-c-21)



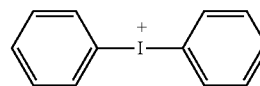
(b2-c-22)



(b2-c-27)

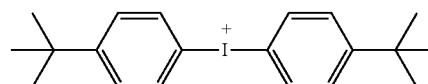
[0419] Examples of the cation represented by the formula (b2-2) include the followings.

(b2-c-23)



(b2-c-28)

(b2-c-24)

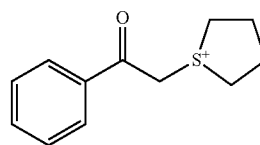


(b2-c-29)

(b2-c-30)

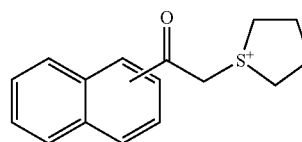
[0420] Examples of the cation represented by the formula (b2-3) include the followings.

(b2-c-25)



(b2-c-31)

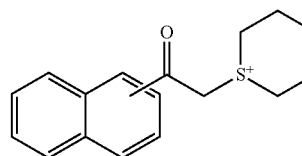
(b2-c-26)



(b2-c-32)

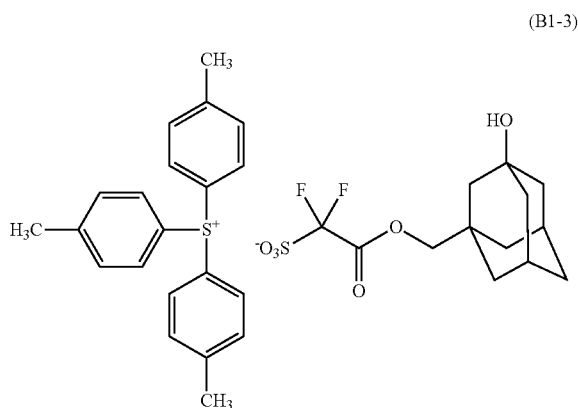
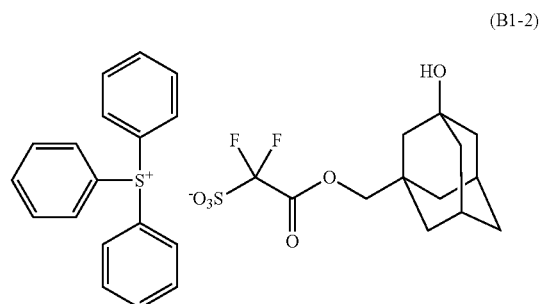
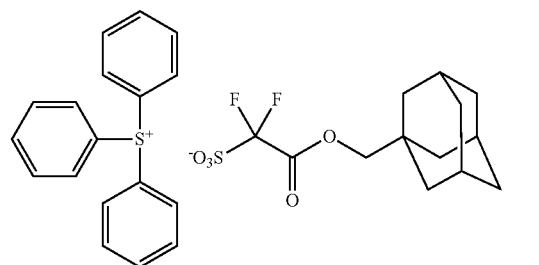
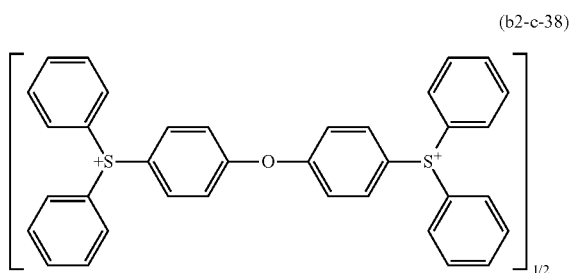
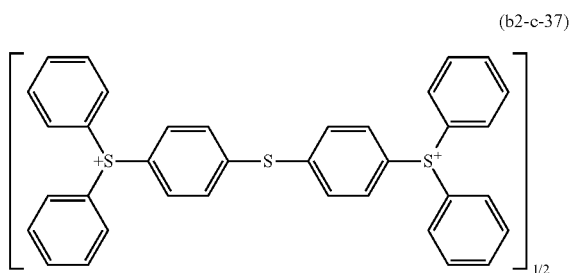
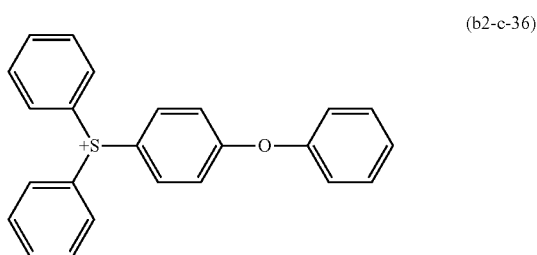
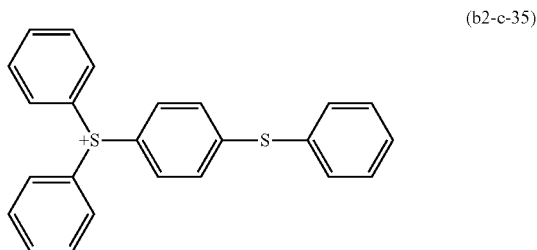
(b2-c-33)

(b2-c-27)



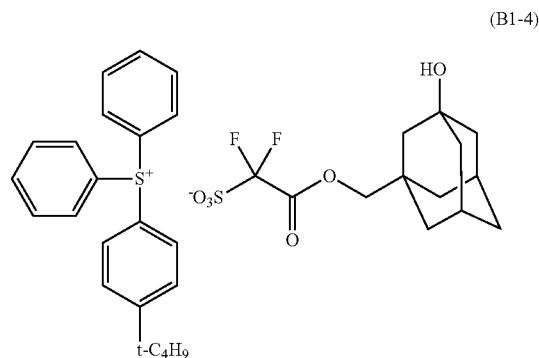
(b2-c-34)

[0421] Examples of the cation represented by the formula (b2-4) include the followings.



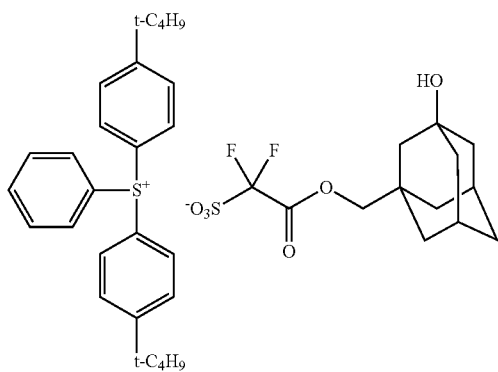
[0422] The acid generator may consist of any one of the above-mentioned sulfonic acid anions and any one of the above-mentioned organic cations. The acid generator preferably consists of one anion selected among those of formulae (B1a-1) to (B1a-3) and (B1a-7) to (B1a-15) and one cation selected from among those of formulae (b1-1-1) and (b2-3).

[0423] Specific examples of the acid generator include the following salts represented by formulae (B1-1) to (B1-28). Among them, those which comprise an arylsulfonium cation are preferred, the salts represented by formulae (B1-1), (B1-2), (B1-3), (B1-5), (B1-6), (B1-7), (B1-11), (31-12), (B1-13), (B1-14), (B1-20), (81-21), (81-22), (B1-23), (B1-24), (B1-25) and (B1-26) are more preferred.



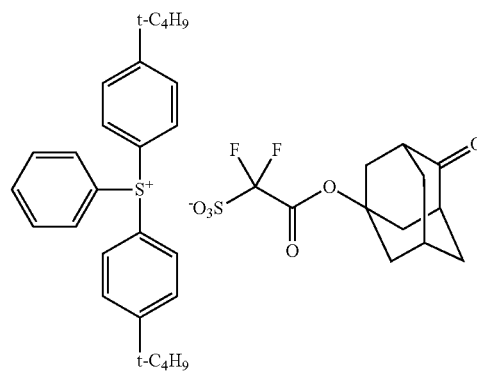
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(B1-5)

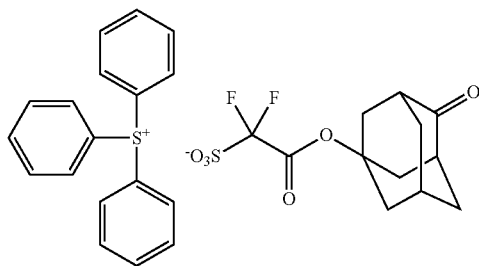


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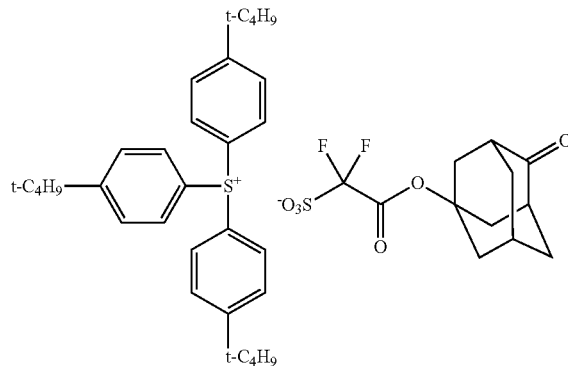
(B1-9)



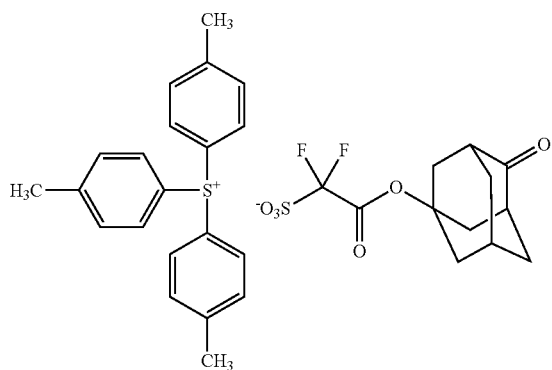
(B1-6)



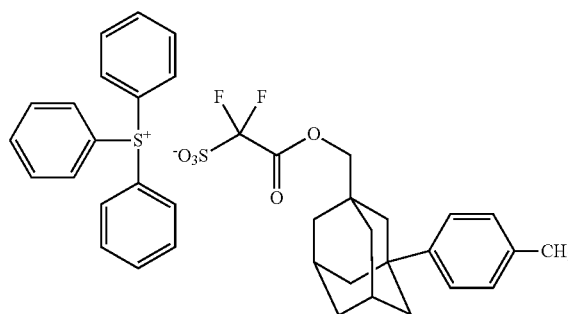
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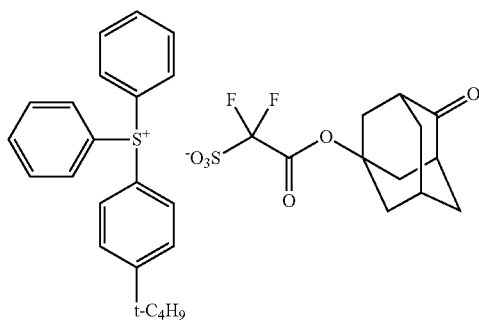
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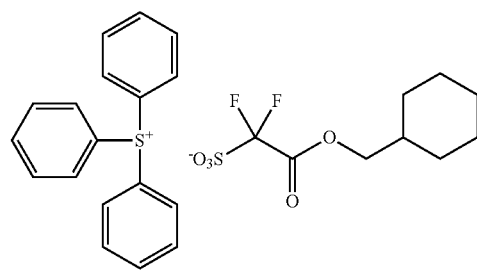
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(B1-8)

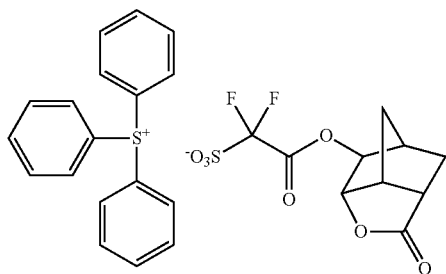


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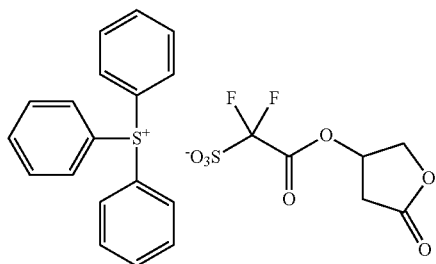


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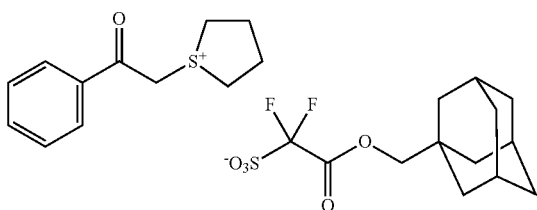
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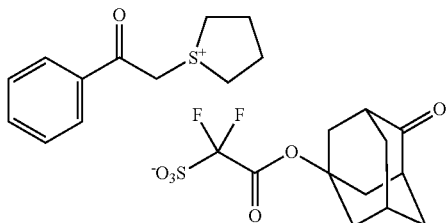
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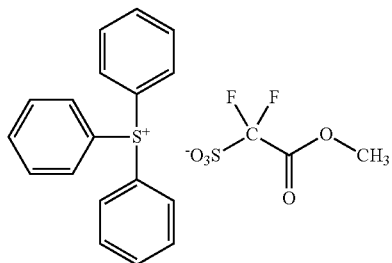
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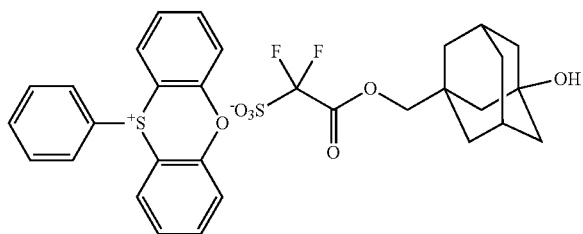
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(B1-17)

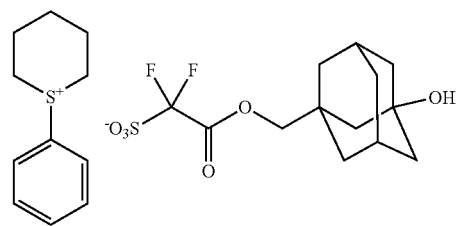


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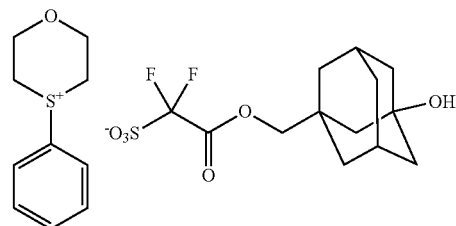


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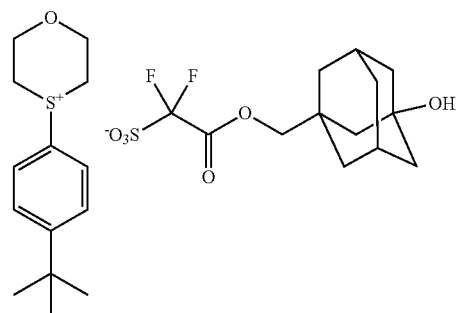
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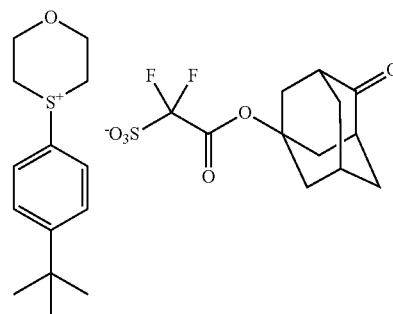
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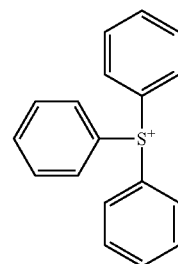
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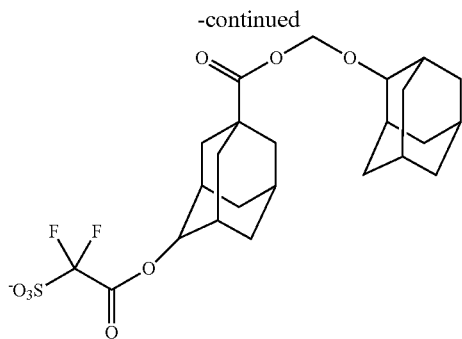


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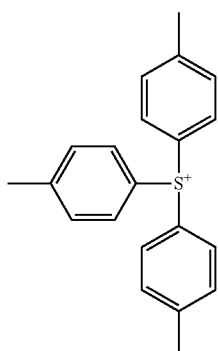


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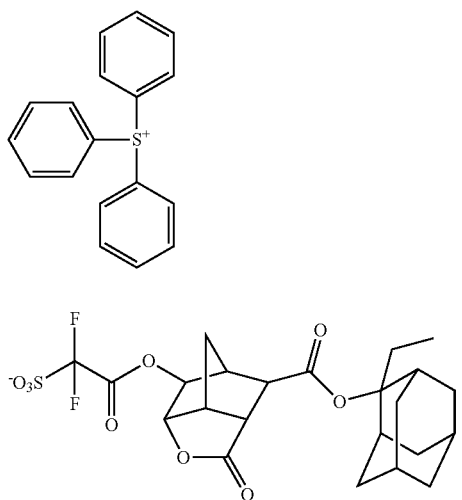




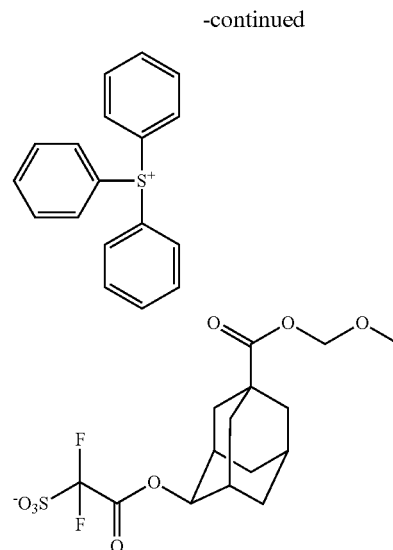
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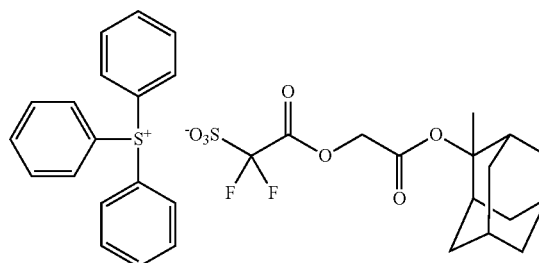
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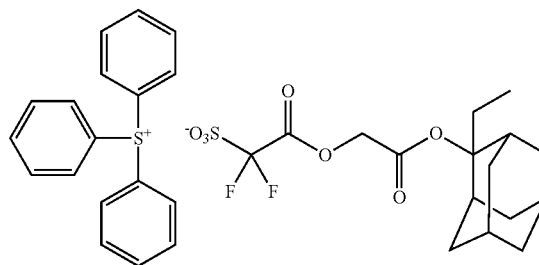
(B1-26)



(B1-27)



(B1-28)



(B1-29)

[0424] The content of the acid generator represented by formula (B1) is preferably 30 parts by mass or more, more preferably 50 parts by mass or more, per 100 parts by mass of the total acid generators. The acid generator for the photoresist composition may consist of the acid generator represented by formula (B1). The total content of the acid generator is preferably 1 part by mass or more, more preferably 3 parts by mass or more, per 100 parts by mass of the resin.

[0425] The photoresist composition of the present invention may comprise a solvent.

[0426] The amount of the solvent is usually 90% by weight or more, preferably 92% by weight or more preferably 94% by weight or more based on total amount of the photoresist composition of the present invention. The amount of the solvent is usually 99.9% by weight or less and preferably 99% by weight or less based on total amount of the photoresist composition of the present invention. The content can be measured with known methods such as liquid chromatography or gas chromatography.

[0427] Examples of the solvent include a glycol ether ester such as ethyl cellosolve acetate, methyl cellosolve acetate and propylene glycol monomethyl ether acetate; a glycol ether such as propylene glycol monomethyl ether; an ester such as ethyl lactate, butyl acetate, amyl acetate and ethyl pyruvate; a ketone such as acetone, methyl isobutyl ketone, 2-heptanone and cyclohexanone; and a cyclic ester such as γ -butyrolactone.

[0428] The photoresist compositions of the present invention may further comprise a quencher such as a basic compound. The "quencher" has the property that it can trap an acid, especially an acid generated from the acid generator by applying a radiation.

[0429] Examples of the quencher include a basic compound, such as a basic nitrogen-containing organic compound, and a salt which generates an acid having acidity weaker than an acid generated from the acid generators.

[0430] Examples of the basic nitrogen-containing organic compound include an amine compound such as an aliphatic amine, an aromatic amine and an ammonium salt. Examples of the aliphatic amine include a primary amine, a secondary amine and a tertiary amine. Examples of the aromatic amine include an aromatic amine.

[0431] Examples of the quencher include 1-naphthylamine, 2-naphthylamine, aniline, diisopropylaniline, 2-, 3- or 4-methylaniline, 4-nitroaniline, N-methylaniline, N,N-dimethylaniline, diphenylamine, hexylamine, heptylamine, octylamine, nonylamine, decylamine, dibutylamine, pentylamine, dioctylamine, triethylamine, trimethylamine, tripropylamine, tributylamine, tripentylamine, trihexylamine, triheptylamine, trioctylamine, trinonylamine, tridecylamine, methyl dibutylamine, methyl dipentylamine, methyl dihexylamine, methyl dicyclohexylamine, methyl diheptylamine, methyl dioctylamine, methyl dinonylamine, methyl didecylamine, ethyl dibutylamine, ethyl dipentylamine, ethyl dihexylamine, ethyl diheptylamine, ethyl dioctylamine, ethyl dinonylamine, ethyl didecylamine, dicyclohexylmethylamine, tris[2-(2-methoxyethoxy)ethyl]amine, triisopropanolamine, ethylenediamine, tetramethylenediamine, hexamethylenediamine, 4,4'-diamino-1,2-diphenylethane, 4,4'-diamino-3,3'-dimethyldiphenylmethane, 4,4'-diamino-3,3'-diethyldiphenylmethane, piperazine, morpholine, piperidine, hindered amine compound having a piperidine structure, 2,2'-methylenebis(aniline), imidazole, 4-methylimidazole, pyridine, 4-methylpyridine, 1,2-di(2-pyridyl)ethane, 1,2-di(4-pyridyl)ethane, 1,2-di(2-pyridyl)ethene, 1,2-di(4-pyridyl)ethene, 1,3-di(4-pyridyl)propane, 1,2-di(4-pyridyloxy)ethane, di(2-pyridyl)ketone, 4,4'-dipyridyl sulfide, 4,4'-dipyridyl disulfide, 2,2'-dipyridylamine, 2,2'-dipicolylamine and bipyridine.

[0432] Examples of the quaternary ammonium hydroxide include tetramethylammonium hydroxide, tetrabutylammonium hydroxide, tetrahexylammonium hydroxide, tetraoctylammonium hydroxide, phenyltrimethylammonium hydroxide, (3-trifluoromethylphenyl)trimethylammonium hydroxide and (2-hydroxyethyl)trimethylammonium hydroxide (so-called "choline").

[0433] Herein, the acidity in the salts is shown by the acid dissociation constant (pKa).

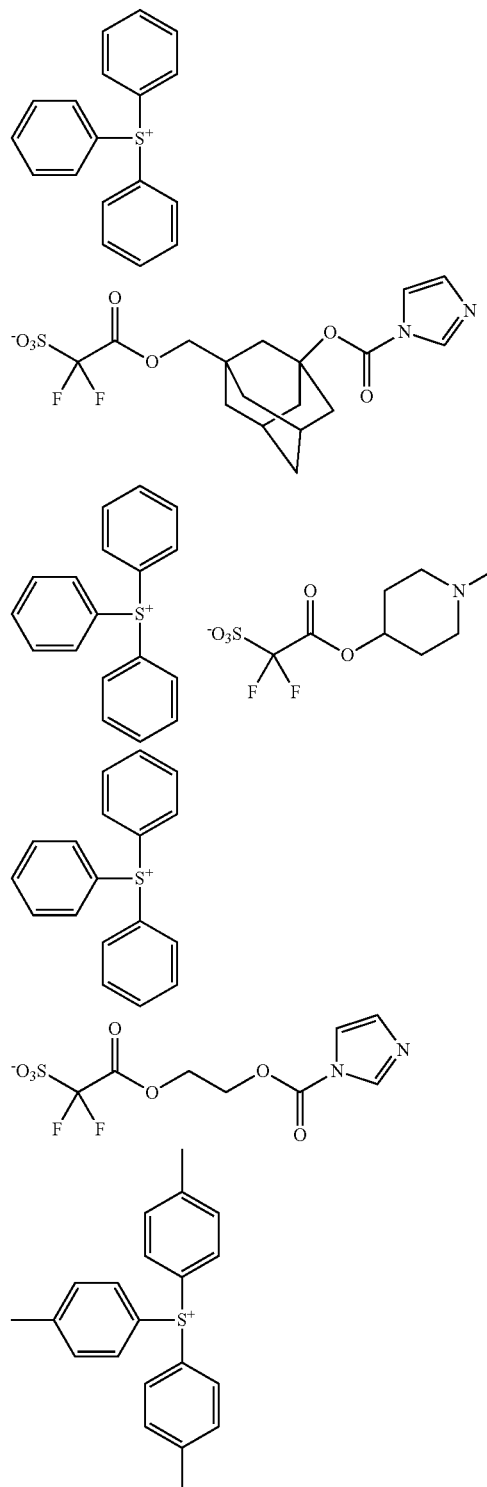
[0434] The acid dissociation constant of acid generated from the salt for a quencher is usually a salt of $-3 < \text{pKa}$.

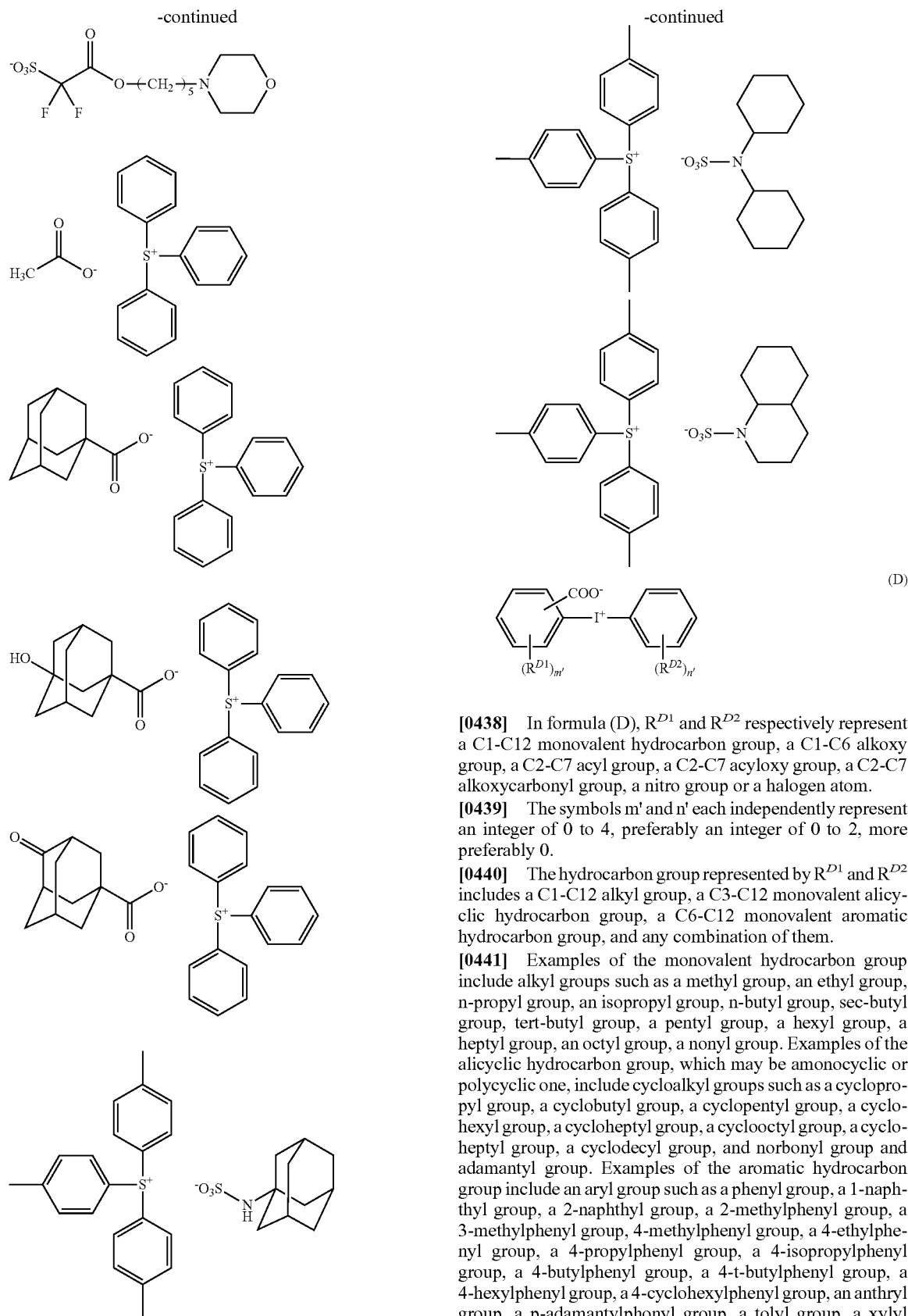
[0435] The salt for a quencher is preferably a salt of $-1 < \text{pKa} < 7$, and more preferably a salt of $0 < \text{pKa} < 5$.

[0436] Specific examples of the salt for a quencher include the following ones, an onium carboxylic acid salt such as the

salt of formula (D), and salts recited in US2012/328986A1, US2011/171576A1, US2011/201823A1, JP2011-39502A1, and US2011/200935A1.

[0437] The photoresist composition comprises preferably onium carboxylic acid salt, more preferably the salt of formula (D).





phenanthryl group, a 2,6-diethylphenyl group and a 2-methyl-6-ethylphenyl group. Examples of the combination include alkyl-cycloalkyl groups, cycloalkyl-alkyl groups, aralkyl groups such as a benzyl group, a 1-phenylethyl group, a 2-phenylethyl group, a 1-phenyl-1-propyl group, a 1-phenyl-2-propyl group, a 2-phenyl-2-propyl group, a 3-phenyl-1-propyl group, a 4-phenyl-1-butyl, a 5-phenyl-1-pentyl group and 6-phenyl-1-hexyl group.

[0442] Examples of alkoxy groups include a methoxy group and an ethoxy group.

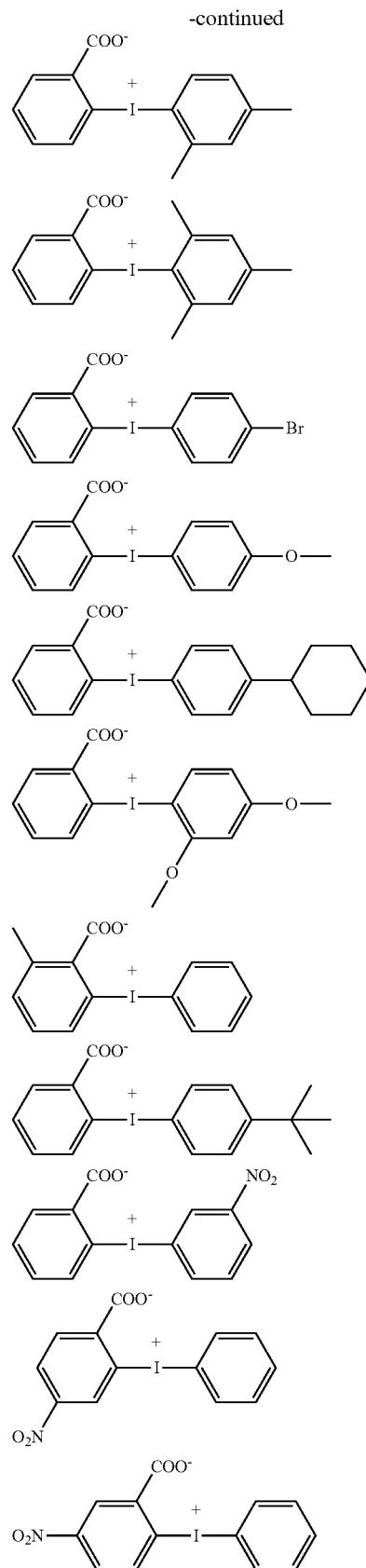
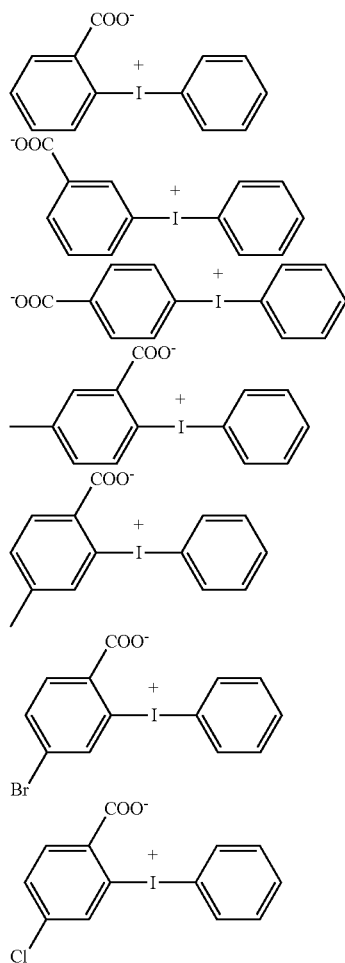
[0443] Examples of acyl groups include an acetyl group, a propanoyl group, a benzoyl group, and a cyclohexanecarbonyl group.

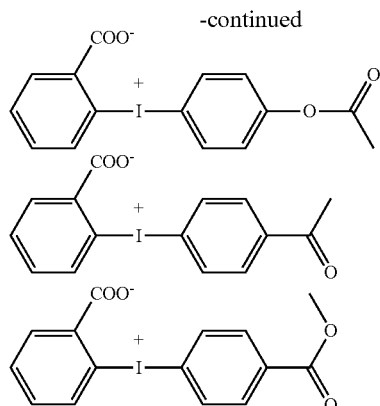
[0444] Examples of acyloxy group include groups where an oxy group [—O—] is attached to any one of the acyl groups as mentioned above.

[0445] Examples of alkoxy carbonyl group include groups where a carbonyl group [—CO—] is attached to any one of the alkoxy groups as mentioned above.

[0446] Examples of halogen atoms include fluorine atoms, a chlorine atom, and a bromine atom.

[0447] Examples of the compounds of formula (D) include the following ones.





[0448] The compound represented by formula (D) can be produced according to the method recited in Tetrahedron vol. 45, No. 19, p 6281-6296. The compound is available on the market.

[0449] The content of quencher is preferably 0.01 to 5% by mass, more preferably 0.01 to 4% by mass, still more preferably 0.01 to 3% by mass, and further more preferably 0.01 to 1% by mass, based on sum of solid component.

[0450] The photoresist compositions of the present invention may comprise, if necessary, a small amount of various additives such as a sensitizer, a dissolution inhibitor, other polymers, a surfactant, a stabilizer and a dye as long as the effect of the present invention is not prevented.

[0451] The photoresist compositions of the present invention can usually be prepared by mixing, in a solvent, an acid generator and Resin (A), and if necessary a quencher, and/or additives at a suitable ratio for the composition, optionally followed by filtrating the mixture with a filter having 0.003 μm to 0.2 μm of a pore size.

[0452] The order of mixing these components is not limited to any specific order. The temperature at mixing the components is usually 10 to 40° C., which can be selected in view of the resin or the like.

[0453] The mixing time is usually 0.5 to 24 hours, which can be selected in view of the temperature. The means for mixing the components is not limited to specific one. The components can be mixed by being stirred.

[0454] The amounts of the components in the photoresist compositions can be adjusted by selecting the amount to be used for production of them.

[0455] The photoresist compositions of the present invention are useful for a chemically amplified photoresist composition.

[0456] The photoresist compositions of the present invention are useful for a chemically amplified photoresist composition.

[0457] A photoresist pattern can be produced by the following steps (1) to (5):

[0458] (1) a step of applying the photoresist composition of the present invention on a substrate,

[0459] (2) a step of forming a composition film by conducting drying,

[0460] (3) a step of exposing the composition film to radiation,

[0461] (4) a step of baking the exposed composition film, and

[0462] (5) a step of developing the baked composition film with an alkaline developer.

[0463] The applying of the photoresist composition on a substrate is usually conducted using a conventional apparatus

such as spin coater. The photoresist composition is preferably filtrated with filter having a pore size of 0.01 to 0.2 μm before applying. Examples of the substrate include a silicon wafer or a quartz wafer on which a sensor, a circuit, a transistor or the like is formed.

[0464] The formation of the composition film is usually conducted using a heating apparatus such as hot plate or a decompressor, and the heating temperature is usually 50 to 200° C. When the pressure is reduced during heating, the operation pressure is usually 1 to 1.0*10⁵ Pa. The heating time is usually 10 to 180 seconds.

[0465] The composition film obtained is exposed to radiation using an exposure system. The exposure is usually conducted through a mask having a pattern corresponding to the desired photoresist pattern. Examples of the exposure source include a light source radiating laser light in a UV-region such as a KrF excimer laser (wavelength: 248 nm), an ArF excimer laser (wavelength: 193 nm) and a F₂ laser (wavelength: 157 nm), and a light source radiating harmonic laser light in a far UV region or a vacuum UV region by wavelength conversion of laser light from a solid laser light source (such as YAG or semiconductor laser).

[0466] The temperature of baking of the exposed composition film is usually 50 to 200° C., and preferably 70 to 150° C.

[0467] The development of the baked composition film is usually carried out using a development apparatus. The development method includes dipping methods, paddle methods, spray methods and dynamic dispense method. The developing temperature is preferably 5 to 60° C., and the developing time is preferably 5 to 300 seconds.

[0468] The positive and negative type photoresist patterns can be obtained by the development depending on a developer to be used therefor.

[0469] When a positive type photoresist pattern is prepared from the photoresist composition of the present invention, the development can be conducted with an alkaline developer. The alkaline developer to be used may be any one of various alkaline aqueous solution used in the art. Generally, an aqueous solution of tetramethylammonium hydroxide or (2-hydroxyethyl)trimethylammonium hydroxide (commonly known as "choline") is often used. The alkaline developer may comprise a surfactant.

[0470] After development, the photoresist film having photoresist pattern is preferably washed with ultrapure water, and the remained water on the photoresist film and the substrate is preferably removed therefrom.

[0471] When a negative type photoresist pattern is prepared from the photoresist composition of the present invention, the development can be conducted with a developer containing an organic solvent, such developer is sometimes referred to as "organic developer".

[0472] Examples of an organic solvent for organic developer include ketone solvents such as 2-hexanone, 2-heptanone; glycolether ester solvents such as propyleneglycolmonomethylether acetate; ester solvents such as butyl acetate; glycolether solvents such as propyleneglycolmonomethylether; amide solvents such as N,N-dimethylacetamide; and aromatic hydrocarbon solvents such as anisole.

[0473] The content of organic solvent is preferably from 90% to 100% by weight, more preferably from 95% to 100% by weight, in an organic developer. Preferred is that the organic developer essentially consists of an organic solvent.

[0474] Among them, the organic developer is preferably a developer comprising butyl acetate and/or 2-heptanone.

[0475] The total content of butyl acetate and 2-heptanone is preferably from 50% to 100% by weight, more preferably

from 90% to 100% by weight. Preferred is that the organic developer essentially consists of butyl acetate and/or 2-heptanone.

[0476] The organic developer may comprise a surfactant or a very small amount of water.

[0477] Development with an organic developer can be stopped by replacing the developer by other solvent than it such as alcohol.

[0478] The photoresist composition of the present invention is suitable for KrF excimer laser lithography, ArF excimer laser lithography, EUV (extreme ultraviolet) lithography, EUV immersion lithography and EB (electron beam) lithography.

EXAMPLES

[0479] The present invention will be described more specifically by Examples, which are not construed to limit the scope of the present invention.

[0480] The “%” and “part(s)” used to represent the content of any component and the amount of any material used in the following examples and comparative examples are on a mass basis unless otherwise specifically noted.

[0481] The weight-average molecular weight of any material used in the following examples was determined with gel permeation chromatography under the following condition.

[0482] Equipment: HLC-8120 GCP type, manufactured by TOSOH CORPORATION

[0483] Column: Three of TSKgel Multipore HXL-M with guard column, manufactured by TOSOH CORPORATION

[0484] Solvent: tetrahydrofuran

[0485] Flow rate: 1.0 mL/min.

[0486] Detector: RI Detector

[0487] Column temperature: 40° C.

[0488] Injection volume: 100 L

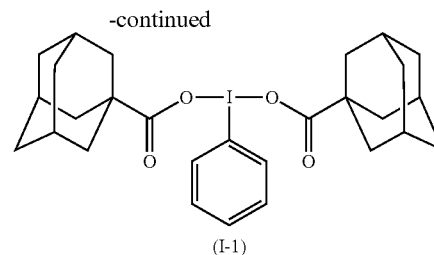
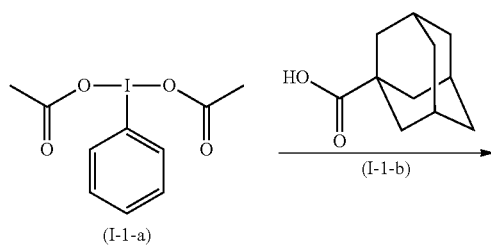
[0489] Standard reference material: Standard polystyrene (manufactured by TOSOH CORPORATION)

[0490] Structures of compounds were determined by mass spectrometry (Liquid Chromatography: 1100 Type, manufactured by AGILENT TECHNOLOGIES LTD., Mass Spectrometry: LC/MSD Type, manufactured by AGILENT TECHNOLOGIES LTD.).

[0491] Here, the values at the peaks of the spectrum are referred to as “MASS”.

Synthesis Example 1

[0492]



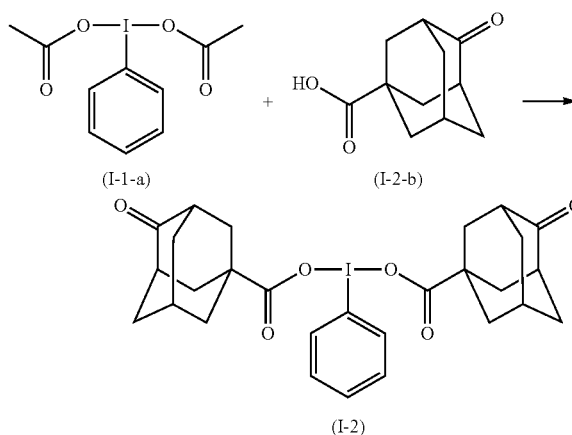
[0493] To a reactor, 4 parts of the compound represented by formula (I-1-a) and 20 parts of monochlorobenzene were added and then they were stirred at 23° C. for 30 minutes. Thereto 6.71 parts of the compound represented by formula (I-1-b) were added and then stirred at 40° C. for 30 minutes, followed by conducting vacuum concentration at 40° C.

[0494] Then the concentrated residues were collected and 15 parts of chloroform and 65 parts of n-heptane were added thereto. Then the obtained mixture was stirred at 23° C. for 30 minutes and then filtrated to obtain 5.35 parts of the compound represented by formula (I-1).

[0495] MASS (Mass Spectrum): 562.2 (molecular ion peak)

Example 1

[0496]



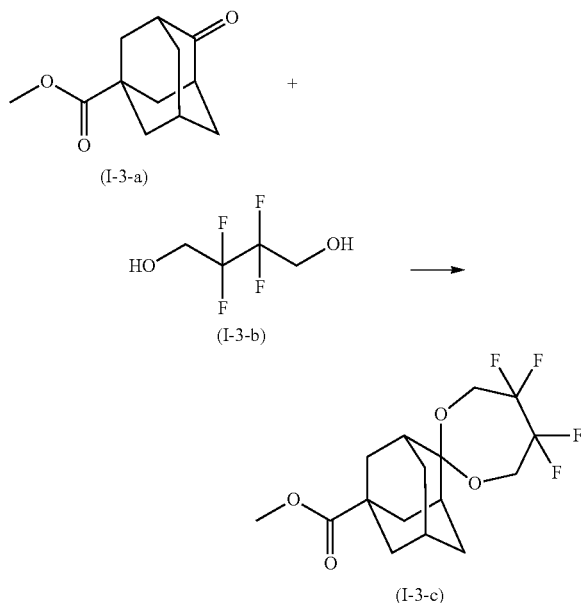
[0497] To a reactor, 4 part of the compound represented by formula (I-1-a) and 20 parts of monochlorobenzene were added and stirred at 23° C. for 30 minutes. Then 7.23 part of the compound represented by formula (I-2-b) were added thereto and then stirred at 40° C. for 30 minutes, followed by conducting vacuum concentration at 40° C.

[0498] Then the concentrated residues were collected and 15 parts of chloroform and 65 parts of n-heptane were added thereto. Then the obtained mixture was stirred at 23° C. for 30 minutes and then filtrated to obtain 5.28 parts of the compound represented by formula (I-2).

[0499] MASS (Mass Spectrum): 590.1 (molecular ion peak)

Example 2

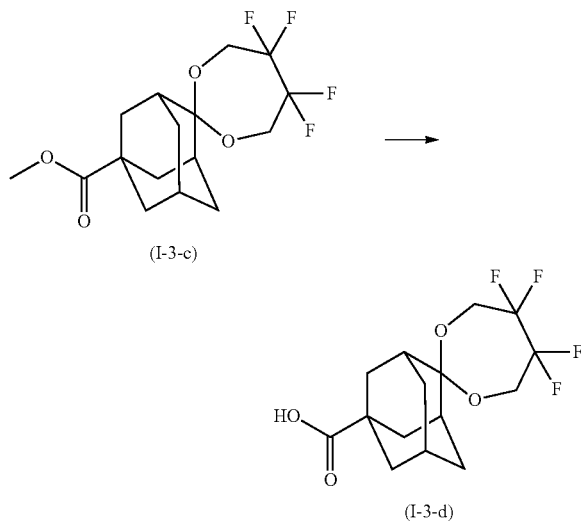
[0500]



[0501] To a reactor, 13.04 parts of compounds represented by formula (I-3-a), 15.22 parts of the compound represented by formula (I-3-b) and parts of chloroform were added and stirred at 23° C. for 30 minutes, and 0.61 parts of sulfuric acid were added thereto. Then the mixture was refluxed at 60° C. for 12 hours at the presence of a molecular sieve and then cooled to 23° C. To the obtained reaction mixture, parts of 10% aqueous potassium carbonate solution were added and then stirred at 23° C. for 30 minutes, followed by being separated by being left.

[0502] TO the collected organic layer, 80 parts of ion exchanged water was added and then stirred at 23° C. for 30 minutes, followed by being separated for collecting an organic layer. This washing step was conducted four times.

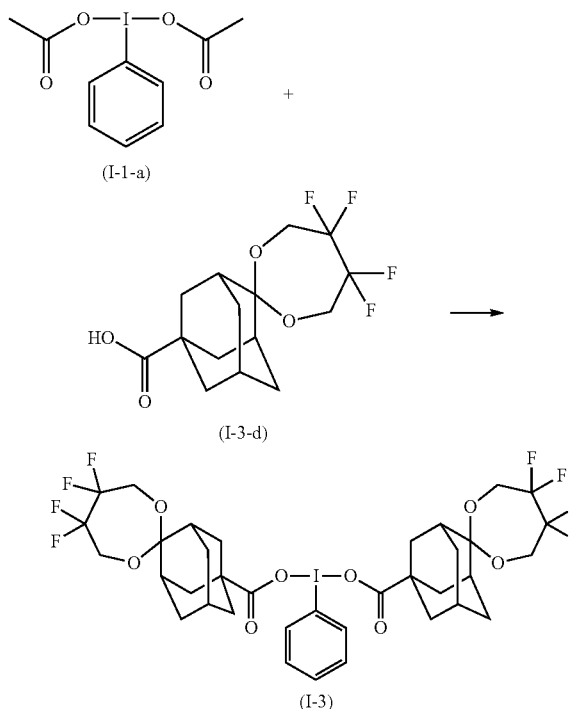
[0503] Then the washed one was concentrated, and 25 parts of methanol and 25 parts of ion exchanged water were added to the concentrated residue and then stirred at 23° C. for 30 minutes, followed by being filtrated to obtain 12.93 parts of the compound represented by formula (I-3-c).



[0504] To a reactor, 12.93 parts of compounds represented by formula (I-3-c) and 65 parts of acetone were added and then stirred at 0° C. for 30 minutes, and 44 parts of 5% aqueous sodium hydroxide solution were added thereto and then stirred at 23° C. for 18 hours.

[0505] To the obtained reaction mixture, 280 parts of 5% aqueous oxalic acid solution and 250 parts of ethyl acetate were added and stirred at 23° C. for 30 minutes, followed by being left for separation. To the separated organic layer, 150 parts of ion exchanged water were added and stirred at 23° C. for 30 minutes, followed by being left for separating into an organic layer: The washing step with water was conducted three times.

[0506] Then the washed layer were concentrated, 50 parts of n-heptane were added to the concentrated residue and then stirred at 23° C. for 30 minutes, followed by being filtrated to obtain 9.54 parts of the compound represented by formula (I-3-d).



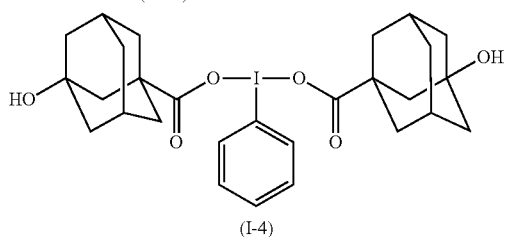
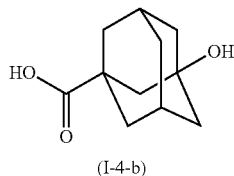
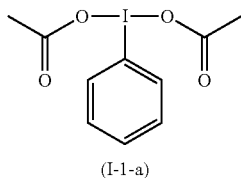
[0507] To a reactor, 2 part of the compound represented by formula (I-1-a) and 20 parts of monochlorobenzene were added and stirred at 23° C. for 30 minutes, and then 6.3 part of the compound represented by formula (I-3-d) were added thereto and then stirred at 40° C. for 30 minutes, followed by conducting vacuum concentration at 40° C.

[0508] Then the concentrated residues were collected and 10 parts of chloroform and 45 parts of n-heptane were fed thereto and stirred at 23° C. for 30 minutes. The obtained mixture was filtrated to obtain 3.12 parts of the compound represented by formula (I-3).

[0509] MASS (Mass Spectrum): 878.2 (molecular ion peak)

Example 3

[0510]

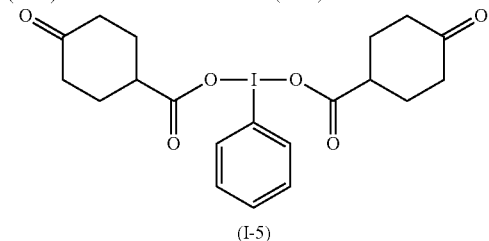
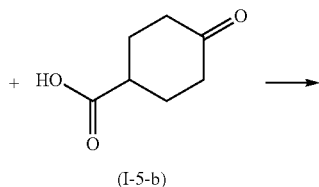
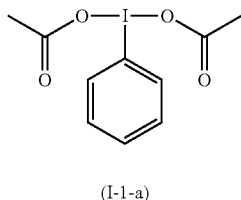


[0511] To a reactor, 4 part of the compound represented by formula (I-1-a) and 20 parts of monochlorobenzene were added and stirred at 23° C. for 30 minutes, and then 7.3 part of the compound represented by formula (I-4-b) were added thereto and then stirred at 40° C. for 30 minutes, followed by conducting vacuum concentration at 40° C. Then the concentrated residues were collected and 15 parts of chloroform and 65 parts of n-heptane were fed thereto and stirred at 23° C. for 30 minutes. The obtained mixture was filtrated to obtain 5.16 parts of the compound represented by formula (I-4).

[0512] MASS (Mass Spectrum): 594.2 (molecular ion peak)

Example 4

[0513]



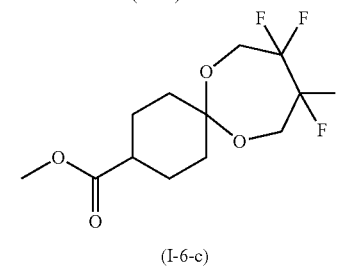
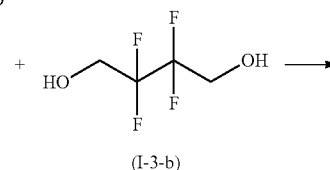
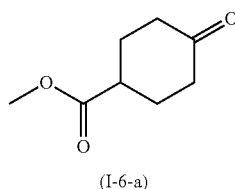
[0514] To a reactor, 4 part of the compound represented by formula (I-1-a) and 20 parts of monochlorobenzene were added and stirred at 23° C. for 30 minutes, and then 5.29 part of the compound represented by formula (I-5-b) were added thereto and then stirred at 40° C. for 30 minutes, followed by

conducting vacuum concentration at 40° C. Then the concentrated residues were collected and 15 parts of chloroform and 65 parts of n-heptane were fed thereto and stirred at 23° C. for 30 minutes. The obtained mixture was filtrated to obtain 3.28 parts of the compound represented by formula (I-5).

[0515] MASS (Mass Spectrum): 486.1 (molecular ion peak)

Example 5

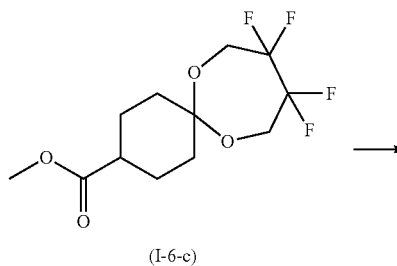
[0516]



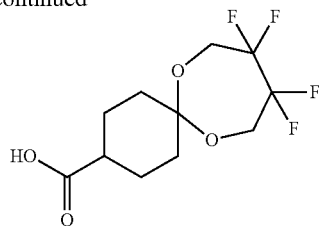
[0517] To a reactor, 9.78 parts of compounds represented by formula (I-6-a), 15.22 parts of the compound represented by formula (I-3-b) and parts of chloroform were added and stirred at 23° C. for 30 minutes, and 0.61 parts of sulfuric acid were added thereto. Then the mixture was refluxed at 60° C. for 8 hours at the presence of a molecular sieve and then cooled to 23° C. To the obtained reaction mixture, parts of 10% aqueous potassium carbonate solution were added and then stirred at 23° C. for 30 minutes, followed by being separated by being left.

[0518] To the collected organic layer, 80 parts of ion exchanged water was added and then stirred at 23° C. for 30 minutes, followed by being separated for collecting an organic layer. This washing step was conducted four times.

[0519] Then the washed one was concentrated and 11.43 parts of the compound represented by formula (I-6-c) were separated from the collected concentrated residue by silica gel column chromatography [silica gel 60N, manufactured by KANTO CHEMICAL, Co., Inc.; spherical shape, neutral, 100-210 m, eluent: chloroform/methanol=1/4].



-continued

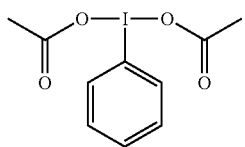


(I-6-d)

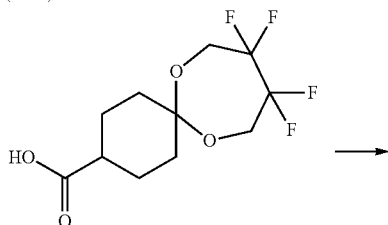
[0520] To a reactor, 11.02 parts of compounds represented by formula (I-6-c) and 65 parts of acetone were added and then stirred at 0° C. for 30 minutes, and 44 parts of 5% aqueous sodium hydroxide solution were added thereto and then stirred at 23° C. for 18 hours.

[0521] To the obtained reaction mixture, 280 parts of 5% aqueous oxalic acid solution and 250 parts of ethyl acetate were added and stirred at 23° C. for 30 minutes, followed by being left for separation. To the separated organic layer, 150 parts of ion exchanged water were added and stirred at 23° C. for 30 minutes, followed by being left for separating into an organic layer: The washing step with water was conducted three times.

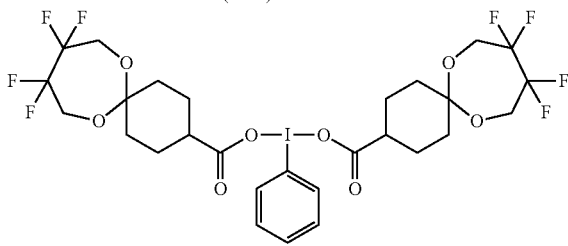
[0522] Then the washed one was concentrated and 9.32 parts of the compound represented by formula (I-6-d) were separated from the collected concentrated residue by silica gel column chromatography [silica gel 60N, manufactured by KANTO CHEMICAL, Co., Inc.; spherical shape, neutral, 100-210 μm, eluent: chloroform/ethyl acetate -1/4].



(I-1-a)



(I-6-d)



(I-6)

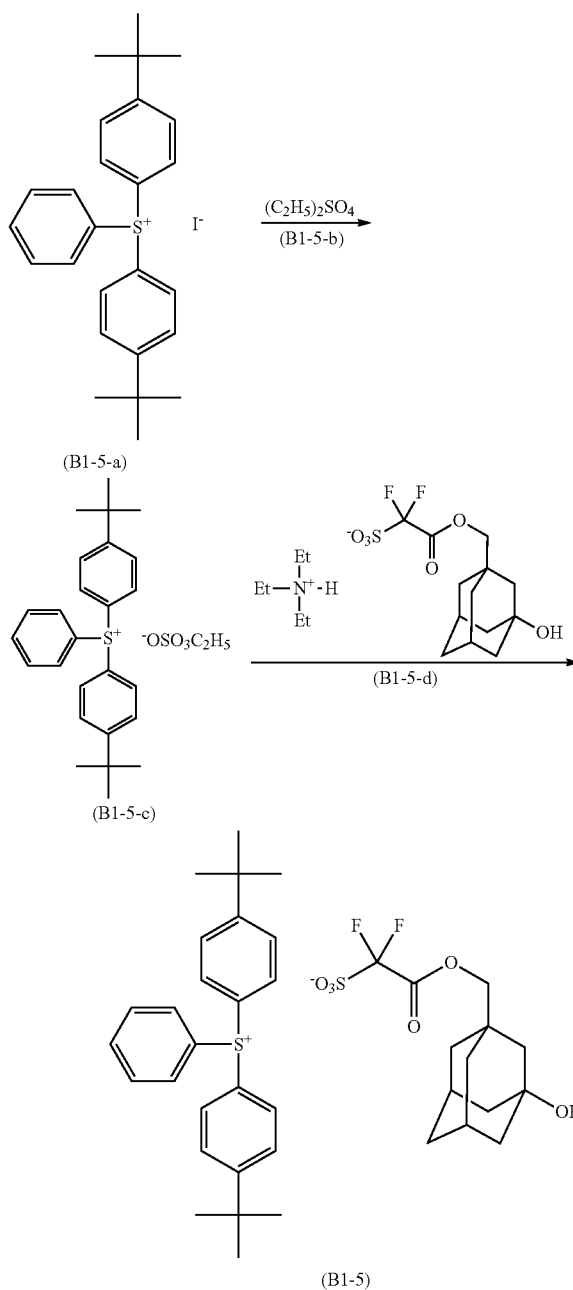
[0523] To a reactor, 2 part of the compound represented by formula (I-1-a) and 20 parts of monochlorobenzene were added and stirred at 23° C. for 30 minutes, and then 5.33 part

of the compound represented by formula (I-6-d) were added thereto and then stirred at 40° C. for 30 minutes, followed by conducting vacuum concentration at 40° C. Then the concentrated residues were collected and 8 parts of chloroform and 33 parts of n-heptane were fed thereto and stirred at 23° C. for 30 minutes. The obtained mixture was filtrated to obtain 7.32 parts of the compound represented by formula (I-6).

[0524] MASS (Mass Spectrum): 774.1 (molecular ion peak)

Synthesis Example 2

[0525]



(B1-5)

[0526] To a reactor, 50.49 parts of the salt represented by formula (B1-5-a) and 252.44 parts of chloroform were added and they were stirred at 23° C. for 30 minutes. Then 16.27 parts of the salt represented by formula (B1-5-b) were dropped thereto and then stirred at 23° C. for an hour to obtain a solution containing the salt represented by formula (B1-5-c).

[0527] To the obtained solution, 48.8 parts of the salt represented by formula (B1-5-d) and 84.15 parts of ion-exchanged water were added then stirred at 23° C. for 12 hours to obtain a reaction solution with two separated phases. Then chloroform layer was separated therefrom, and 84.15 parts of ion-exchanged water were added thereto for washing: This washing step was conducted 5 times.

[0528] To the washed chloroform layer, 3.88 parts of active carbon were added and then they were stirred, followed by conducting filtration. The collected filtrate was concentrated. To the obtained residue, 125.87 parts of acetonitrile was added and stirred, followed by being concentrated.

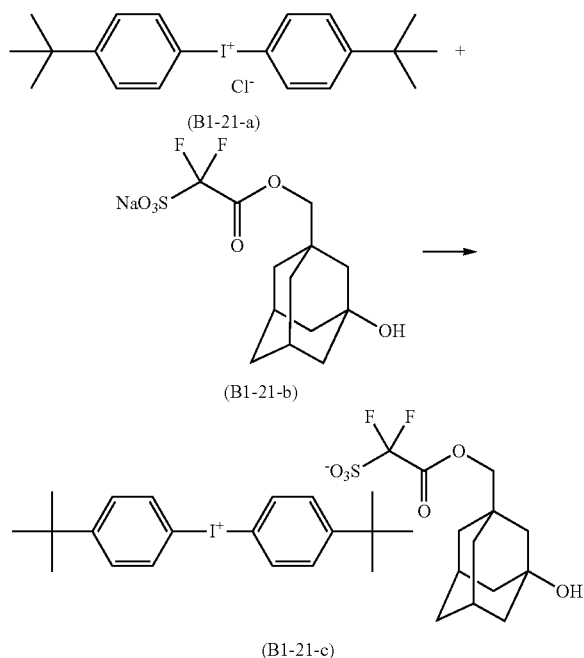
[0529] To the obtained residue, 20.62 parts of acetonitrile and 309.30 parts of tert-butylmethylether were added and stirred at 23° C. for 30 minutes, followed by removing its supernatant therefrom. Then To the residue, 200 parts of n-heptane were added and stirred at 23° C. for 30 minutes, followed by being filtrated to obtain 61.54 parts of the salt represented by formula (B1-5).

[0530] MASS (ESI(+)) Spectrum): M⁺ 375.2

[0531] MASS (ESI(-)) Spectrum): M⁺ 339.1

Synthesis Example 3

[0532]

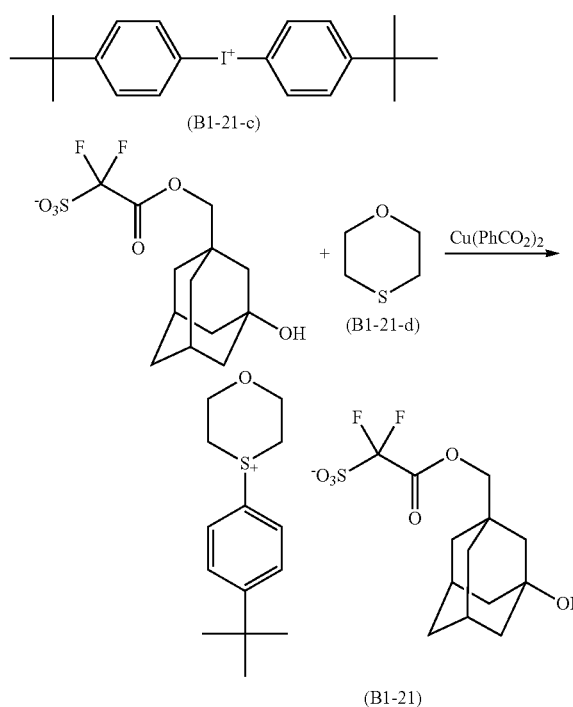


[0533] In a reactor, 30.00 parts of the salt represented by formula (B1-21-b) which had been produced according to the method described in JP 2008-209917 A, 35.50 parts of the salt represented by formula (B1-21-a), 100 parts of chloroform and 50 parts of ion-exchanged water were fed and stirred at

23° C. for 15 hours. From the obtained reaction mixture which had two phases, a chloroform phase was collected with separation.

[0534] The chloroform phase was washed with 30 parts of ion-exchanged water for washing: This washing was conducted five times.

[0535] The washed chloroform phase was concentrated. To the obtained residue, 100 parts of tert-butylmethylether were added and then stirred at 23° C. for 30 minutes, followed by being filtrated to obtain 48.57 parts of the salt represented by formula (B1-21-c).



[0536] Into a reactor, 20.00 parts of the salt represented by formula (31-21-c), 2.84 parts of the compound represented by formula (B1-21-d) and 250 parts of monochlorobenzene were fed and then they were stirred at 23° C. for 30 minutes.

[0537] To the resultant mixture, 0.21 part of copper (II) dibenzoate was added. The resultant mixture was stirred at 100° C. for 1 hour. The mixture was concentrated, and then 200 parts of chloroform and 50 parts of ion-exchanged water were added to the obtained residue, followed by being stirred at 23° C. for 30 minutes. Then the organic phase was collected by separation. The organic layer was washed with 50 parts of ion-exchanged water and then they were stirred at 23° C. for 30 minutes, followed by collecting an organic phase by separation: This washing was conducted five times.

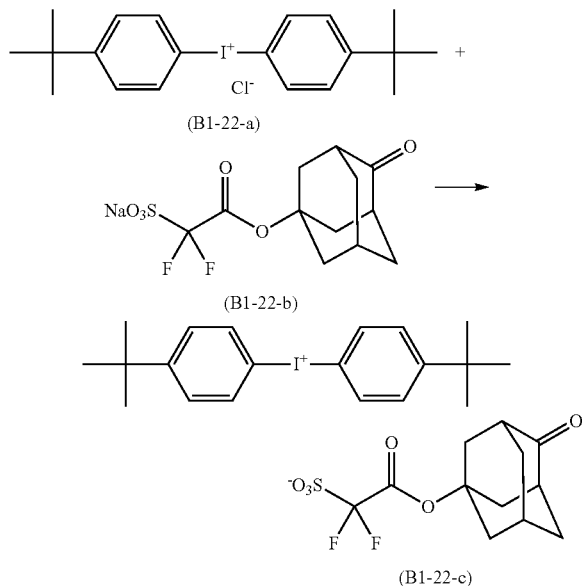
[0538] The washed organic layer was concentrated. To the residue, 53.51 parts of acetonitrile was added, and the resultant mixture was concentrated. To the residue, 113.05 parts of tert-butylmethylether was added and then they were stirred, followed by being filtrated to obtain 10.47 parts of the salt represented by formula (B1-21).

[0539] MASS (ESI(+)) Spectrum): M⁺ 237.1

[0540] MASS (ESI(-)) Spectrum): M⁻ 339.1

Synthesis Example 4

[0541]



[0542] Into a reactor, 11.26 parts of the salt represented by formula (B1-22-a), 10.00 parts of the compound represented by formula (B1-22-b), 50 parts of chloroform and 25 parts of ion-exchanged water were fed and then they were stirred at 23° C. for 15 hours. From the obtained reaction mixture which had two phases, a chloroform phase was collected with separation.

[0543] The chloroform phase was washed with 15 parts of ion-exchanged water for washing: This washing was conducted five times.

[0544] The washed chloroform phase was concentrated. To the obtained residue, 50 parts of tert-butylmethylether was added and then stirred at 23° C. for 30 minutes, followed by being filtrated to obtain 11.75 parts of the salt represented by formula (B1-22-c).

[0545] Into a reactor, 11.71 parts of the salt represented by formula (B1-22-c), 1.70 parts of the compound represented by formula (B1-22-d) and 46.84 parts of monochlorobenzene were fed and then they were stirred at 23° C. for 30 minutes.

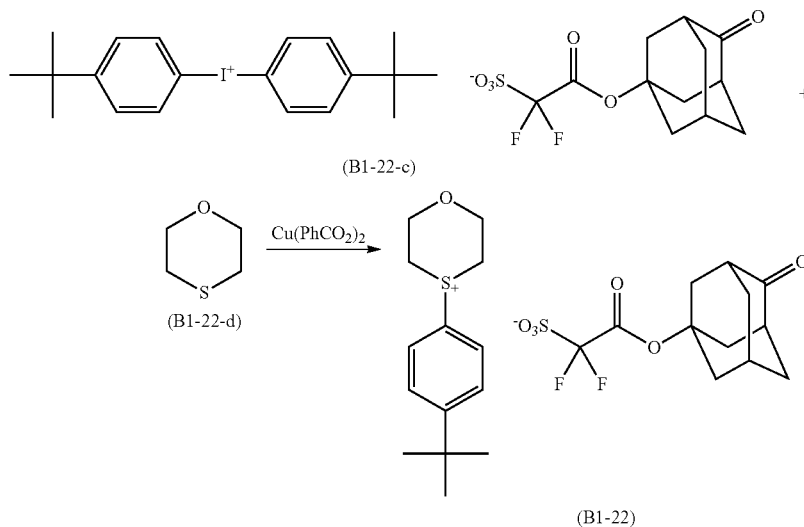
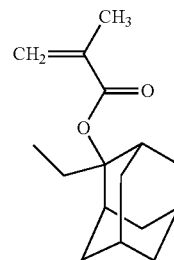
[0546] TO the resultant mixture, 0.12 part of copper (II) dibenzoate were added. The resultant mixture was stirred at 100° C. for 30 minutes. The mixture was concentrated, and then 50 parts of chloroform and 12.50 parts of ion-exchanged water were added to the obtained residue, followed by being stirred at 23° C. for 30 minutes. Then the organic phase was collected by separation. The organic layer was washed with 12.50 parts of ion-exchanged water and then they were stirred at 23° C. for 30 minutes, followed by collecting an organic phase by separation: This washing was conducted eight times.

[0547] The washed organic layer was concentrated. To the residue, 50 parts of tert-butylmethylether was added, followed by being filtrated to obtain 6.84 parts of the salt represented by formula (B1-22).

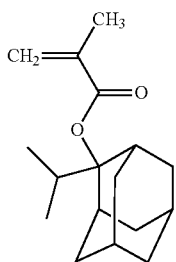
[0548] MASS (ESI(+)) Spectrum): M^+ 237.1

[0549] MASS (ESI(-)) Spectrum): M^- 323.0

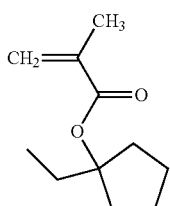
[0550] Compounds used as monomers in the following Synthesis Examples are shown as follow.



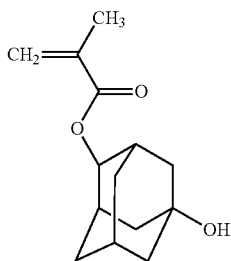
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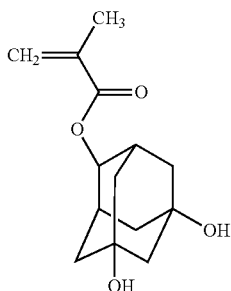
(a1-1-3)



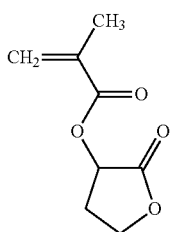
(a1-2-9)



(a2-1-1)

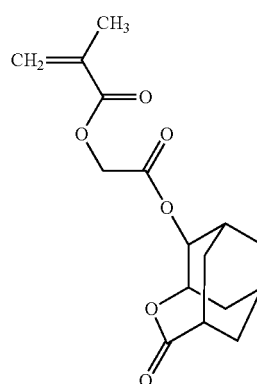


(a2-1-3)

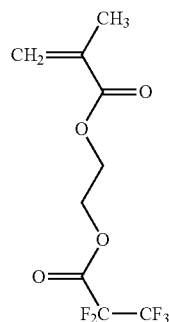


(a3-1-1)

-continued



(a3-4-2)



(a4-1-7)

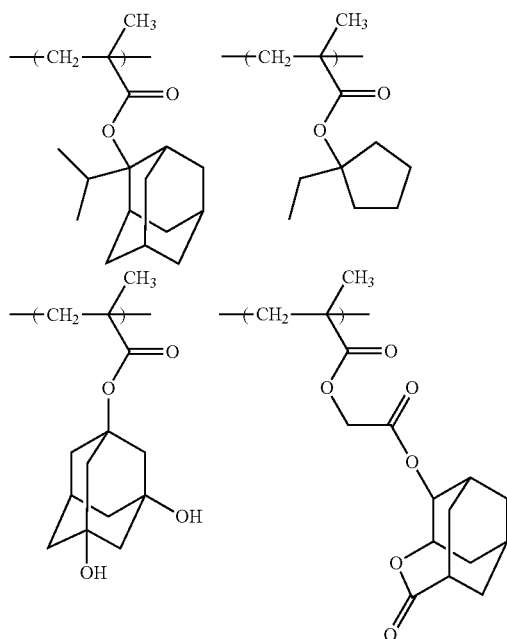
[0551] Here, each of the compounds is referred as to “monomer (X)” where “X” is the symbol of the formula representing the monomer.

Synthesis Example 5

[0552] There were mixed monomers (a1-1-3), (a1-2-9), (a2-1-3) and (a3-4-2) in a molar ratio of 45/14/2.5/38.5 (monomer (a1-1-3)/monomer (a1-2-9)/monomer (a2-1-3)/monomer (a3-4-2)) as well as propyleneglycolmonomethyl-ether acetate in 1.5 times part based on total parts of all monomers to prepare a mixture. To the mixture, azobisisobutyronitrile in the ratio of 1 mol % based on all monomer molar amount and azobis(2,4-dimethylvaleronitrile) in the ratio of 3 mol % based on all monomer molar amount were added as initiators, and the obtained mixture was heated at 73° C. for about 5 hours. The reaction mixture was poured into a large amount of a mixture of methanol and water to cause precipitation. The precipitate was collected by filtration.

[0553] Then the filtrates were dissolved in propyleneglycolmonomethyl-ether acetate and the resultant solution was poured into a large amount of a mixture of methanol and water to cause precipitation, followed by being filtrated: This operation was conducted twice for purification.

[0554] As a result, a resin having a weight-average molecular weight of about 7.6×10^3 was obtained in yield of 68%. This resin is called as Resin A1. Resin A1 had the following structural units.



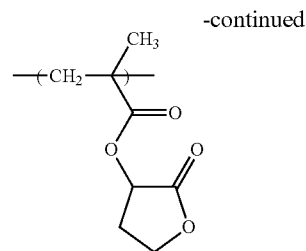
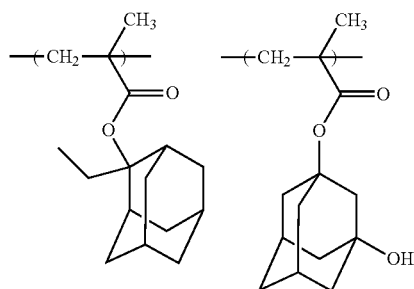
Synthesis Example 6

[0555] There were mixed monomers (a1-1-2), (a2-1-1) and (a3-1-1) in a molar ratio of 50/25/25 [monomer (a1-1-2)/monomer (a2-1-1)/monomer (a3-1-1)] as well as propyleneglycolmonomethylether acetate in 1.5 times part based on total parts of all monomers to prepare a mixture.

[0556] To the mixture, azobisisobutyronitrile in the ratio of 1 mol % based on all monomer molar amount and azobis(2,4-dimethylvaleronitrile) in the ratio of 3 mol % based on all monomer molar amount were added as initiators, and the obtained mixture was heated at 75° C. for about hours. The reaction mixture was poured into a large amount of a mixture of methanol and water to cause precipitation. The precipitate was collected by filtration.

[0557] Then the filtrates were dissolved in propyleneglycolmonomethylether acetate and the resultant solution was poured into a large amount of a mixture of methanol and water to cause precipitation, followed by being filtrated: This operation was conducted twice for purification.

[0558] As a result, a resin having a weight-average molecular weight of about 9.1×10^3 was obtained in yield of 66%. This resin is called as resin A2. Resin A2 had the following structural units.



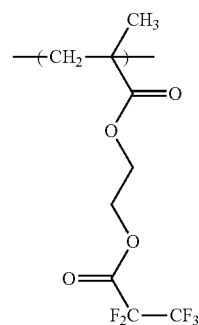
Synthesis Example 7

[0559] There were mixed monomer (a4-1-7) and 1,4-dioxane in 1.5 times part based on total parts of all monomers to prepare a mixture. TO the mixture, azobisisobutyronitrile in the ratio of 0.7 mol % based on all monomer molar amount and azobis(2,4-dimethylvaleronitrile) in the ratio of 2.1 mol % based on all monomer molar amount were added as initiators, and the obtained mixture was heated at 75° C. for about 5 hours.

[0560] The reaction mixture was poured into a large amount of a mixture of methanol and water to cause precipitation. The precipitate was collected by filtration.

[0561] Then the reaction mixture was poured into a large amount of a mixture of methanol and water to cause precipitation. The precipitate was collected by filtration: This operation was conducted twice for purification.

[0562] As a result, a resin having a weight-average molecular weight of about 1.8×10^4 was obtained in yield of 77%. This resin is called as resin X1. Resin X1 had the following structural unit.



Examples 6 to 14 and Comparative Example 1

Production of Photoresist Compositions

[0563] The following components as listed in Table 1 were mixed and dissolved in the solvent as mentioned below, and then filtrated through a fluorine resin filter having pore diameter of 0.2 μm , to prepare photoresist compositions.

TABLE 1

Comp. No.	Resin (kind/amount (part))	Acid generator (kind/amount (part))	Compound of formula (I) (kind/amount (part))	Quencher (kind/amount (part))	PB (° C.) / PEB (° C.)
Comp. 1	A1/10	B1-5/0.40	I-3/0.15	D1/0.34	90/90
	X1/0.7	B1-22/0.40			
Comp. 2	A1/10	B1-21/0.95	I-3/0.15	D1/0.34	90/90
	X1/0.7	B1-22/0.40			

TABLE 1-continued

Comp. No.	Resin (kind/amount (part))	Acid generator (kind/amount (part))	Compound of formula (I) (kind/amount (part))	Quencher (kind/amount (part))	PB (° C./PEB (° C.))
Comp. 3	A1/10 X1/0.7	B1-21/0.95 B1-22/0.40	I-2/0.15	D1/0.34	90/90
Comp. 4	A1/10 X1/0.7	B1-21/0.95 B1-22/0.40	I-1/0.15	D1/0.34	90/90
Comp. 5	A2/10 X1/0.7	B1-21/0.95 B1-22/0.40	I-3/0.15	D1/0.34	125/125
Comp. 6	A2/10	B1-3/0.85	I-3/0.12	D1/0.10	125/125
Comp. 7	A1/10 X1/0.7	B1-21/0.95 B1-22/0.40	I-4/0.15	D1/0.34	90/90
Comp. 8	A1/10 X1/0.7	B1-21/0.95 B1-22/0.40	I-5/0.15	D1/0.34	90/90
Comp. 9	A1/10 X1/0.7	B1-21/0.95 B1-22/0.40	I-6/0.15	D1/0.34	90/90
Compar. Comp. 1	A2/10	B1-3/0.85	None	C1/0.12 D1/0.10	125/125

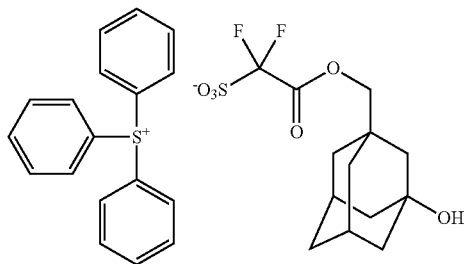
[0564] In Table 1, each of symbols represents the following component:

<Resin>

A1: Resin A1, A2: Resin A2, X1: Resin X1

<Acid Generator>

[0565] B1-3: Salt represented as follow



B1-5: Salt represented by formula (B1-5)

B1-21: Salt represented by formula (B1-21)

B1-22: Salt represented by formula (B1-22)

5-<Compound (I)>

[0566] I-1: The compound represented by formula (I-1)

I-2: The compound represented by formula (I-2)

I-3: The compound represented by formula (I-3)

I-4: The compound represented by formula (I-4)

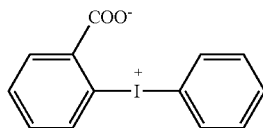
I-5: The compound represented by formula (I-5)

I-6: The compound represented by formula (I-6)

<Quencher>

[0567] C1: 2,6-diisopropylaniline, which was manufactured by Tokyo Chemical Industries, Co., Ltd.

D1: The compound of the following formula, which was manufactured by Tokyo Chemical Industries, Co., Ltd.



<Solvent>

[0568] Mixture of the following solvents

propyleneglycolmonomethylether acetate	265 parts
propyleneglycolmonomethylether	20 parts
2-heptanone	20 parts
γ-butyrolactone	3.5 parts

<Evaluation>

[0569] Silicon wafers (12 inches) were each coated with "ARC-29", which is an organic anti-reflective coating composition available from Nissan Chemical Industries, Ltd., and then baked at 205° C. for 60 seconds, to form a 78 nm-thick organic anti-reflective coating. Each of the photoresist compositions prepared as above was spin-coated over the anti-reflective coating so that the thickness of the resulting film became 85 nm after drying. The silicon wafers thus coated with the respective photoresist compositions were each pre-baked on a direct hotplate at a temperature shown in the column "PB" in Table 1 for 60 seconds. Using an ArF excimer stepper for immersion exposure ("XT: 1900Gi" manufactured by ASML, NA=1.35, ¾ Annular, X-Y polarization), each wafer thus formed with the respective resist film was subjected to exposure with the exposure quantity being varied stepwise. For the exposure, a photomask for forming a line-and-space pattern was used. Ultrapure water was used as an immersion medium.

[0570] After the exposure, each wafer was subjected to post-exposure baking on a hotplate at a temperature shown in the column "PEB" in Table 1 for 60 seconds and then to paddle development at 23° C. for 60 seconds with 2.38% by weight of aqueous tetramethylammonium hydroxide solution to make a photoresist pattern.

[0571] Effective sensitivity (ES): It was expressed as the exposure quantity that the line width of the line-and-space pattern became 50 nm after exposure and development.

Evaluation of Line Edge Roughness [LER]:

[0572] The photoresist pattern obtained in the above-mentioned manner with the exposure whose exposure quantity was the effective sensitivity was observed with a scanning electron microscope.

[0573] The difference in the height between the highest point and the lowest point as to the scabrous wall surface of each photoresist pattern was measured.

[0574] When the difference is 4.5 nm or less, LER is good and its evaluation is marked by "○". When the difference is more than 4.5 nm, LER is bad and its evaluation is marked by "X". Further, each of the differences is also shown in parentheses in a column of "LER". The difference was shown in parentheses in Table 2.

Focal Margin [DOF]:

[0575] The photoresist patterns were obtained in the above-mentioned manner with the exposure whose exposure quantity is the effective sensitivity, with the focal point distance being varied stepwise. Each of patterns developed on the organic anti-reflective coating substrate after the development were observed and the focal point distances when the patterns of which line width were within 50 nm±5% (between 47.5 nm and 52.5 nm) were measured and the difference

