

COMPOUNDS HAVING PHENOL SUBSTITUENTS, PROCESS FOR PRODUCING THE COMPOUND, AND RESIST COMPOSITION COMPRISING THE COMPOUND

BACKGROUND OF THE INVENTION

5 Field of the Invention

The present invention relates to compounds having phenol substituents, a process for producing the compounds, and a resist composition containing the compounds. More particularly, the present invention relates to compounds having novel phenol substituents, including specific substituents which contain acid-dissociable
10 functional groups in the phenolic hydroxyl group, a process for producing the compounds, and a resist composition which is useful in the field of microprocessing using lithography, and particularly, a resist composition which contains the compounds having phenol substituents and is useful as a resist composition for extreme ultraviolet radiation.

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Description of Related Art

Recently in the field of microprocessing of semiconductors and the like using lithography, ultrafine patterns having a line width of 0.10 micrometers or less are demanded in the production of ultra-large-scale integration or the like, along with the
20 progress in high integration of devices. Accordingly, the exposure wavelength requires even shorter wavelengths than the conventionally used region of g-rays or i-rays, and thus attention is being paid to the studies on lithography using far-ultraviolet radiation, KrF excimer laser light, ArF excimer laser light, extreme ultraviolet (EUV) radiation, X-rays and electron beams.

25 In particular, EUV lithography is under development as a patterning technology

of the second-generation, or even of the third-generation, and there is a demand for the development of high sensitivity, high resolution positive type resist.

Higher sensitivity makes it possible to form a pattern even with a low energy light source. However, if sensitivity is not satisfactory, a higher energy light source will be required, and in this regard, the demand for an increase in the sensitivity of the resist is related to the light source of EUV. Furthermore, the demand for the increase in the sensitivity of the resist is also directly related to the speed of wafer processing, because it is not easy to enhance the performance of a light source. Specifically, reflectors are used with EUV because of the property of electron beam that its light is absorbed by every material; however, since even the reflectors do not exhibit a reflection efficiency of 100%, an enhancement of the performance of light source faces great difficulties. Therefore, in order to shorten the time for wafer processing, sensitivity increase of resist compositions constitutes a very important problem.

In the positive type resists for EUV, sensitivity, resolution and line edge roughness are all in a trade-off relationship, and therefore, if it is intended to attempt an increase in the sensitivity, a decrease in the resolution as well as deterioration of the line edge roughness may occur. Accordingly, there is a strong demand for the development of a resist which simultaneously satisfies the characteristics of sensitivity, resolution and line edge roughness, and a compound that is included in the resist composition.

As the compounds used in general resist materials for g-rays, i-rays, KrF and ArF, copolymers obtained by chemically amplified resist (CAR) type radical polymerization constitute the mainstream. For example, when a resist thin film produced by applying a solution of a polymeric resist material such as polymethyl methacrylate, a polyhydroxystyrene having an acid-dissociable reactive group, or polyalkyl methacrylate, is irradiated with ultraviolet radiation, far-ultraviolet radiation,

electron beam, EVU, X-radiation or the like, a line pattern having a line width of about 45 to 100 nm is produced.

However, polymeric resists formed from copolymers have molecular weights as large as about 10,000 to 100,000, and also have large molecular weight distributions.

5 Therefore, these polymeric resists have a disadvantage that the fine patterns of resist developed by a lithographic process making use of polymeric resists, have large line edge roughness, thus it being difficult to control the dimension of the patterns, and as a result, the product yield is decreased. Therefore, the lithographic processes utilizing conventional polymeric resist materials have limitations in the micronization of pattern.

10 Various materials are being used in order to realize finer patterns using EUV, and examples include polymers based on the conventional copolymers but having lower molecular weights; photoacid generator (PAG)-binding polymers intended to increase resolution by a uniform distribution of a photoacid generator; and molecular glass resists making use of monomolecular substances having relatively low molecular weights.
15 Among them, disclosed as the monomolecular resist materials are calixarene compounds, of which the method for production, intermediates and compositions are disclosed in the invention filed under Korean Patent Application No. 10-2006-0132922.

However, a resist composition containing the foregoing compounds that are currently disclosed, has problems such as low resistance to etching, a large amount of
20 exhaust gas, low solubility in the safety solvents used in semiconductor production processes, and poor resist pattern shape. In particular, since good pattern shape having high sensitivity and high resolution is in a complementary relationship with good line edge roughness, there is a demand for the development of a novel material which is capable of satisfying these characteristics at the same time.

SUMMARY OF THE INVENTION

It is an object of the present invention to provide a novel compound having a phenol substituent formed by introducing an acid-dissociable functional group to at least one phenolic hydroxyl group, which compound is suitable for high sensitivity resist compositions.

It is another object of the present invention to provide a method for producing the compound having a phenol substituent.

It is still another object of the present invention to provide a resist composition containing the compound having a phenol substituent and a photoacid generator.

DETAILED DESCRIPTION OF THE INVENTION

Hereinafter, the present invention will be described in detail so that a person having ordinary skill in the related technical art can easily carry out the invention. However, the present invention can be realized in various different embodiments, and the embodiments are not limited to the Examples that will be described hereinbelow.

The terms as used in the present specification are defined as follows.

Unless particularly stated otherwise herein, a halogen atom means any one selected from the group consisting of fluorine, chlorine, bromine and iodine.

Unless particularly stated otherwise herein, the term halogenated means that the relevant substituent contains a halogen atom.

Unless particularly stated otherwise herein, the term alkyl group means to include a primary alkyl group, a secondary alkyl group and a tertiary alkyl group.

Unless particularly stated otherwise herein, the prefix "ar-" means that the relevant substituent contains an aryl group. For example, an aralkyl group means that a hydrogen atom of an alkyl group has been substituted by an aryl group.

Unless particularly stated otherwise herein, the term aryl group means a hydrocarbon having one or two or more aromatic rings. For example, an aryl group means a benzyl group, a naphthyl group or the like.

All of the compounds or substituents mentioned in the present specification may
5 be substituted or unsubstituted, unless particularly stated otherwise. Here, the term "substituted" means that a hydrogen atom has been replaced by any one selected from the group consisting of a halogen atom, a hydroxyl group, a carboxyl group, an alkoxy group, a nitrile group, an aldehyde group, an epoxy group, an ether group, an ester group, a carbonyl group, an acetal group, a ketone group, an alkyl group, a perfluoroalkyl group, a
10 cycloalkyl group, a heterocycloalkyl group, an allyl group, a benzyl group, an aryl group, a heteroaryl group, an aralkyl group, a heteroaralkyl group, derivatives thereof and combinations thereof.

Unless particularly stated otherwise herein, the prefix "hetero-" means that one to three heteroatoms selected from the group consisting of nitrogen (N), oxygen (O),
15 sulfur (S) and phosphorus (P) are substituted on a carbon atom. For example, a heteroalkyl group means that 1 to 3 atoms among the carbon atoms of an alkyl group have been substituted by heteroatom(s), and a heteroaryl group means that 1 to 3 atoms among the carbon atoms of an aryl group have been substituted by heteroatom(s).

Unless particularly stated otherwise herein, an alkyl group means a linear or
20 branched alkyl group having 1 to 30 carbon atoms, a cycloalkyl group means a cycloalkyl group having 3 to 32 carbon atoms, and a heterocycloalkyl group means a heterocycloalkyl group having 2 to 32 carbon atoms. An aryl group means an aryl group having 6 to 30 carbon atoms, a heteroaryl group means a heteroaryl group having 2 to 30 carbon atoms, an aralkyl group means an aralkyl group having 7 to 30 carbon
25 atoms, and a heteroaralkyl group means a heteroaralkyl group having 3 to 30 carbon

atoms.

Unless particularly stated otherwise herein, an aliphatic compound is an organic compound having 1 to 30 carbon atoms, which does not have a cyclic structure of carbon atoms in the molecule, but has a chain-like structure having carbon atoms bound in a line. Aliphatic compounds are classified into alkanes in which the molecular chain is composed of single bonds only; alkenes in which the molecular chain contains double bonds; alkynes in which the molecular chain contains triple bonds; and the like, and further examples include chain-like hydrocarbons, higher fatty acids and esters thereof, and the like.

Aliphatic cyclic compounds are those that are not aromatic compounds, among the compounds having carbon atoms arranged in a ring shape. An aliphatic cyclic compound contains one or more saturated or unsaturated carbon rings, and has 3 to 30 carbon atoms.

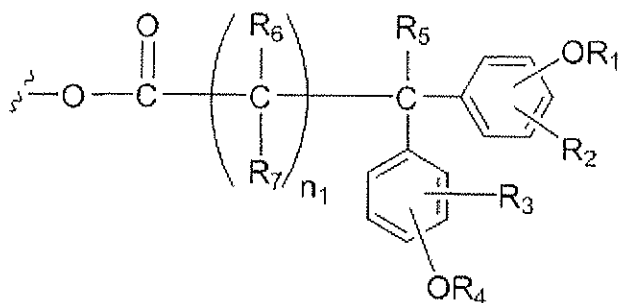
An aromatic compound is an organic compound having 6 to 30 carbon atoms and having a benzene ring in the molecule, and thus is a derivative of benzene. Such aromatic compounds include benzene, xylene, toluene and the like, and many of the aromatic compounds have two or more benzene rings in the molecule. There are also compounds in which two or more benzene rings are each independently separated, such as biphenyl and diphenylmethane, and compounds having a condensed ring type structure, such as naphthalene and anthracene.

Unless particularly stated otherwise herein, an ether means an ether having 2 to 30 carbon atoms, an aldehyde means an aldehyde having 1 to 20 carbon atoms, and a ketone means a ketone having 1 to 20 carbon atoms. An ester means an ester having 1 to 20 carbon atoms, an amide means an amide having 1 to 20 carbon atoms, and an acid anhydride means an acid anhydride having 2 to 20 carbon atoms. A halide means a

halide having 1 to 20 carbon atoms, and an alcohol means an alcohol having 1 to 20 carbon atoms.

According to an embodiment of the present invention, there is provided a compound having a phenol substituent represented by the following formula (1):

5 [Formula 1]



wherein R_2 and R_3 each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;

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R_5 to R_7 each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a hydroxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;

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n_1 is an integer from 1 to 30, and may be preferably an integer from 1 to 15, and more preferably an integer from 1 to 5; and

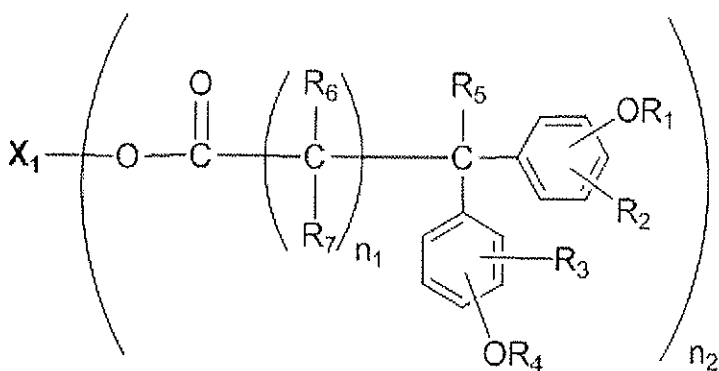
R_1 and R_4 are each independently an acid-dissociable functional group.

The compound having a phenol substituent, as represented by the formula (1), is specifically a compound having a phenol substituent represented by the following formula (2).

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In the following formula (2), n_2 means that n_2 pieces of hydrogen atoms of the following X_1 have been substituted by the phenol substituent represented by the formula (1).

[Formula 2]



wherein R_2 and R_3 each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;

R_5 to R_7 each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a hydroxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;

n_1 is an integer from 1 to 30, and may be an integer from 1 to 15, and more preferably an integer from 1 to 5;

n_2 is an integer from 1 to 30, and may be an integer from 1 to 14, and more preferably an integer from 1 to 8;

R_1 and R_4 are each independently an acid-dissociable functional group; and

X_1 is any one compound selected from the group consisting of an aliphatic

compound, an aliphatic cyclic compound, an aromatic compound, an ether, an aldehyde, a ketone, a carboxylic acid, an ester, an amide, an acid anhydride, a halide and an alcohol.

In the formula (2), X_1 is preferably any one selected from the group consisting of an aliphatic compound having 3 to 30 carbon atoms, an aliphatic cyclic compound having 3 to 30 carbon atoms, an aromatic compound having 6 to 30 carbon atoms, an ether, an aldehyde, a ketone, a carboxylic acid, an ester, an amide, an acid anhydride, a halide and an alcohol.

In the formula (2), X_1 may be substituted or unsubstituted, as previously mentioned in the definition used in the present specification. More specifically, X_1 may be such that a hydrogen atom contained in X_1 has been substituted by any one selected from the group consisting of an alkyl group having 1 to 20 carbon atoms, an alkoxy group having 1 to 20 carbon atoms, a perfluoroalkyl group having 1 to 4 carbon atoms, a hydroxyalkyl group having 1 to 10 carbon atoms, and a cyano group having 1 to 10 carbon atoms. Furthermore, the substituent itself which substitutes a hydrogen atom contained in X_1 may be such that a hydrogen atom in the substituent has been substituted with a substituent previously mentioned in the definition used in the present specification, and may have been substituted with any one selected from the group consisting of an ether group, an ester group, a carbonyl group, an acetal group, an epoxy group, a nitrile group and an aldehyde group.

Examples of X_1 include 1,3-propanediol, pentaerythritol, dipentaerythritol, 1,4-benzenedimethanol, phloroglucinol, 1,3-dihydroxypropan-2-one (1,3-dihydroxyacetone dimer), 2,5-dihydroxydioxane dimer, and the like, or may be compounds in which all or a part of the hydrogen atoms of X_1 have been substituted by the phenol substituents represented by the formula (1).

The acid-dissociable functional group in the formula (1) and the formula (2) means a functional group having the property of being dissociated from the compound by an acid.

The acid-dissociable functional group plays a role of making the compound having a phenol substituent insoluble in an alkali aqueous solution. At the same time, the acid-dissociable functional group plays a role of increasing the solubility of the compound having a phenol substituent in an alkali aqueous solution while being dissociated from the phenol substituent by the acid generated from a photoacid generator by exposure.

The acid-dissociable functional group may substitute all or a part of the hydrogen atoms of the phenol substituents, and may preferably substitute all or a part of the hydrogen atoms of the hydroxyl groups of the phenol substituents.

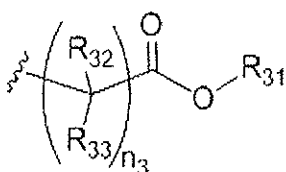
The phenol substituent can have 5% to 100% of the hydrogen atoms in the phenol substituents substituted with the acid-dissociable functional group, and can have 20% to 100% of the hydrogen atoms in the phenol substituents substituted with the acid-dissociable functional group. The phenol substituent can also have 5% to 100% of the hydrogen atoms of the hydroxyl groups in the phenol substituents substituted with the acid-dissociable functional group, and can have 20% to 100% of the hydrogen atoms of the hydroxyl groups in the phenol substituents substituted with the acid-dissociable functional group. When the acid-dissociable functional group is contained at a proportion in the range mentioned above, the solubility in the alkali aqueous solution after exposure can be regulated to an appropriate range.

Any acid-dissociable functional group can be used, as long as it is used as an acid-dissociable substituent in those compounds contained in resist compositions. As for the acid-dissociable functional group, any appropriate functional group can be

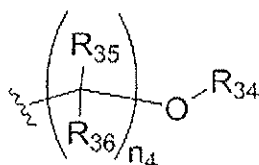
selected and used in consideration of good acid-dissociability, heat resistance, the cross-sectional surface shape of the patterned resist layer, and the like.

In the compound containing a phenol substituent represented by the formula (1), R_1 and R_4 can be each independently any one selected from the group consisting of the following formula (3a) and formula (3b):

[Formula 3a]



[Formula 3b]



In the formula (3a) and formula (3b), n_3 and n_4 are each independently an integer from 0 to 10, and may be preferably an integer from 0 to 3.

R_{32} , R_{33} , R_{35} and R_{36} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group; preferably any one selected from the group consisting of a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, a heteroalkyl group having 1 to 10 carbon atoms, a cycloalkyl group having 3 to 12 carbon atoms, a heterocycloalkyl group having 1 to 10 carbon atoms, an aryl group having 6 to 20 carbon atoms, an aralkyl group having 6 to 20 carbon atoms, a heteroaryl group having 3 to 20 carbon atoms, and a heteroaralkyl group having 3 to 30 carbon atoms; and more preferably any one selected from the group consisting of a hydrogen atom, an alkyl group having 1 to 5 carbon atoms, and a

heteroalkyl group having 1 to 5 carbon atoms.

R_{31} and R_{34} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a heteroalkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group. Preferably, R_{31} and R_{34} are each independently a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, a heteroalkyl group having 1 to 10 carbon atoms, a cycloalkyl group having 3 to 13 carbon atoms and a heterocycloalkyl group having 3 to 13 carbon atoms, and more preferably any one selected from the group consisting of a hydrogen atom, an alkyl group having 1 to 8 carbon atoms, a heteroalkyl group having 4 to 8 carbon atoms, a cycloalkyl group having 4 to 13 carbon atoms, and a heterocycloalkyl group having 4 to 13 carbon atoms.

Specifically, when R_{31} and R_{34} are each independently an alkyl group, R_{31} and R_{34} may be each an isobutyl group, a tert-butyl group, an isopentyl group, a neopentyl group, a tert-pentyl group, an isohexyl group, a neohexyl group or the like. When R_{31} and R_{34} are each independently a heteroalkyl group, R_{31} and R_{34} may be each an isobutyl group, a tert-butyl group, an isopentyl group, a neopentyl group, a tert-pentyl group, an isohexyl group, a neohexyl group or the like, each being substituted with 1 to 3 oxygen atoms.

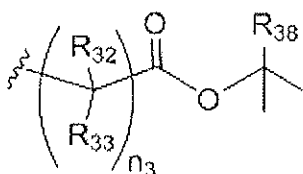
Furthermore, when R_{31} and R_{34} are each independently a cycloalkyl group or a heterocycloalkyl group, the cycloalkyl group or the heterocycloalkyl group may be monocyclic or polycyclic, and may have 3 to 20 carbon atoms, preferably 4 to 14 carbon atoms, and more preferably 5 to 12 carbon atoms.

The hydrogen atoms contained in R_{31} and R_{34} may be each independently substituted or unsubstituted as previously defined in the definition used in the present specification, and in the case of being substituted, the substituent that substitutes the

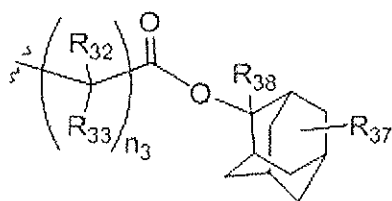
hydrogen atoms contained in R_{31} and R_{34} may be preferably any one selected from the group consisting of a halogen atom, an alkyl group having 1 to 5 carbon atoms, a halogenated alkyl group, a ketone group and combinations thereof.

Specifically, the substituent represented by the formula (3a) can be any one
 5 selected from the group consisting of the following formula (3a-1) to formula (3a-9):

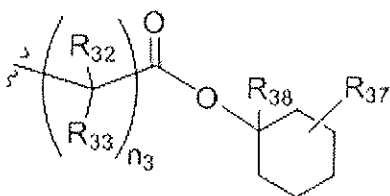
[Formula 3a-1]



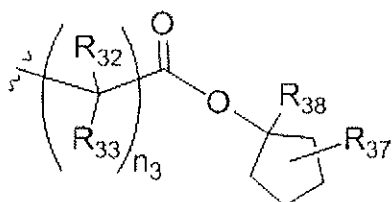
[Formula 3a-2]



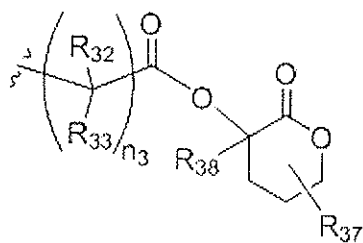
10 [Formula 3a-3]



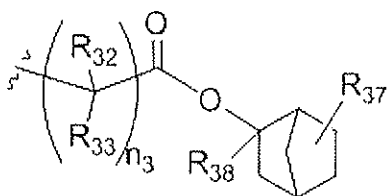
[Formula 3a-4]



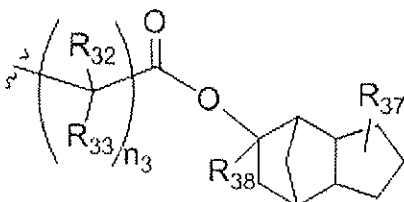
[Formula 3a-5]



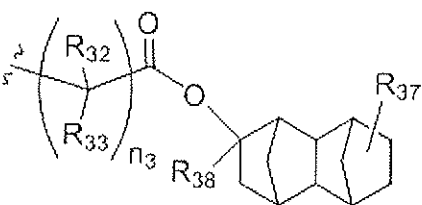
[Formula 3a-6]



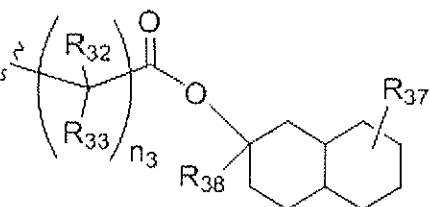
[Formula 3a-7]



[Formula 3a-8]



[Formula 3a-9]



10 In the formula (3a-1) to formula (3a-9), n_3 is an integer from 0 to 10, preferably an integer from 0 to 5, and more preferably an integer from 0 to 3.

R_{32} and R_{33} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl

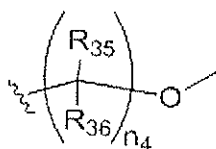
group, an aralkyl group, a heteroaryl group and a heteroaralkyl group, and may be preferably each independently any one selected from the group consisting of a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, a heteroalkyl group having 1 to 10 carbon atoms, a cycloalkyl group having 3 to 12 carbon atoms, a heterocycloalkyl group having 1 to 10 carbon atoms, an aryl group having 6 to 20 carbon atoms, an aralkyl group having 6 to 20 carbon atoms, a heteroaryl group having 3 to 20 carbon atoms and a heteroaralkyl group having 3 to 20 carbon atoms, and more preferably any one selected from the group consisting of a hydrogen atom and an alkyl group having 1 to 5 carbon atoms.

R_{37} and R_{38} may be each independently any one selected from the group consisting of a hydrogen atom and an alkyl group having 1 to 10 carbon atoms, and preferably any one selected from the group consisting of a hydrogen atom and an alkyl group having 1 to 5 carbon atoms.

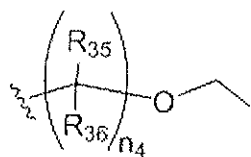
R_{37} and R_{38} may be specifically a linear or branched alkyl group such as a methyl group, an ethyl group, a propyl group, an isopropyl group, an n-butyl group, an isobutyl group, a tert-butyl group, a pentyl group, an isopentyl group or a neopentyl group.

Furthermore, the substituent represented by the formula (3b) can be any one selected from the group consisting of the following formula (3b-1) to formula (3b-13):

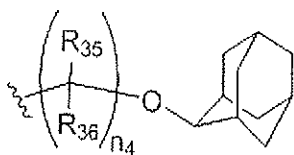
[Formula 3b-1]



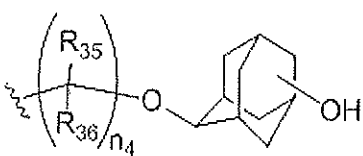
[Formula 3b-2]



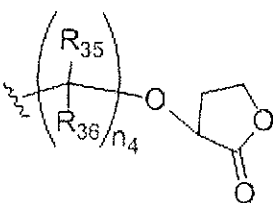
[Formula 3b-3]



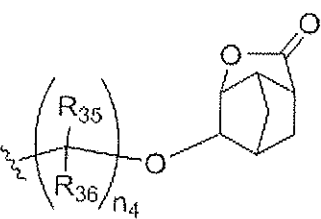
[Formula 3b-4]



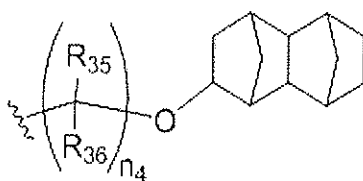
[Formula 3b-5]



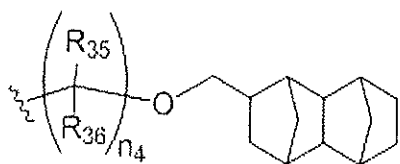
[Formula 3b-6]



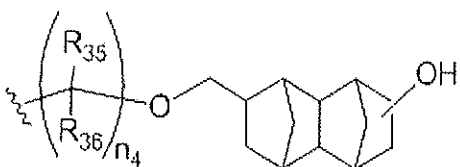
[Formula 3b-7]



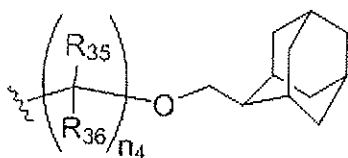
[Formula 3b-8]



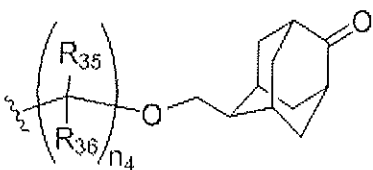
[Formula 3b-9]



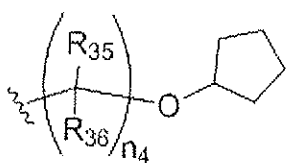
[Formula 3b-10]



[Formula 3b-11]



[Formula 3b-12]



[Formula 3b-13]

In the formula (3b-1) to formula (3b-13), n_4 is an integer from 0 to 10, and preferably n_4 may be an integer from 0 to 5.

R_{35} and R_{36} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group.

In the formula (2), the phenol substituent represented by the formula (1) can
5 substitute a hydrogen atom at any position as long as the hydrogen atoms belongs to X_1 , and the phenol substituent can substitute all or a part of the hydrogen atoms of X_1 , and preferably substitute the hydrogen atoms located at the end of the main chain or a side chain of X_1 .

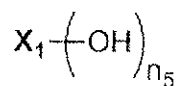
A compound having the phenol substituent described above is characterized by
10 having high heat resistance, being amorphous, and being non-sublimable.

According to another embodiment of the present invention, there is provided a method for producing a compound having a phenol substituent, the method including
subjecting a compound represented by the following formula (4) and a compound
represented by the following formula (5) to an esterification reaction, and thereby
15 producing a compound represented by the following formula (2).

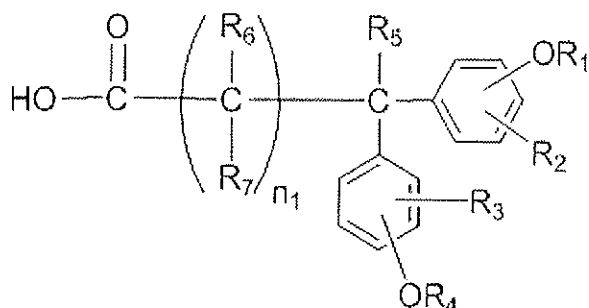
In the explanations that will follow, any matter marked by the same reference
character or symbol as those introduced in connection with the compound having a
phenol substituent according to the previous embodiment of the present invention is
applicable with the subject matters relating to the compound having a phenol substituent
20 according to the previous embodiment of the present invention.

The compound represented by the following formula (4) represents that n_5
pieces of hydrogen atoms of X_1 shown below have been substituted by hydroxyl groups
(-OH).

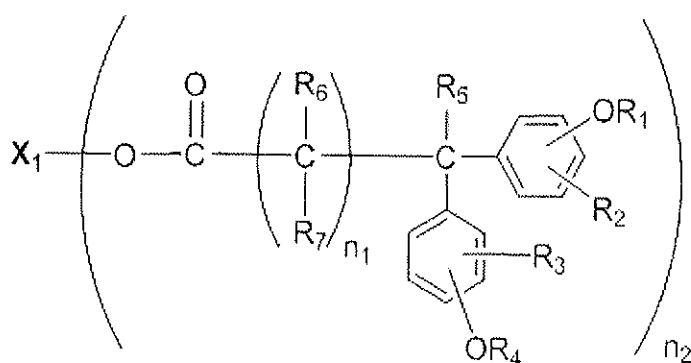
[Formula 4]



[Formula 5]



[Formula 2]



5

In the formula (4), formula (5) and formula (2), n_1 is an integer from 1 to 30, and may be preferably an integer from 1 to 15, and more preferably an integer from 1 to 5.

n_5 is an integer from 1 to 30, and may be preferably an integer from 1 to 14, and more preferably an integer from 1 to 8.

10 R_1 and R_4 are each independently an acid-dissociable functional group.

X_1 is any one compound selected from the group consisting of an aliphatic compound, an aliphatic cyclic compound, an aromatic compound, an ether, an aldehyde, a ketone, a carboxylic acid, an ester, an amide, an acid anhydride, a halide and an alcohol.

15 R_2 and R_3 are each independently any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a nitrile group, an aldehyde group,

an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group.

R_5 to R_7 are each independently any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a hydroxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group.

n_2 is an integer from 1 to 30, and may be preferably an integer from 1 to 14, and more preferably an integer from 1 to 8.

The compound represented by the formula (4) may be an alcohol having a valency of 2 or greater, and specifically, the compound may be any one selected from the group consisting of 1,3-propanediol, pentaerythritol, dipentaerythritol, 1,4-benzenedimethanol, phloroglucinol, 1,3-dihydroxypropan-2-one (1,3-dihydroxyacetone dimer), and 2,5-dihydroxydioxane dimer.

In the esterification reaction described above, the compound of the formula (5) can react with a part of the hydroxyl groups contained in the formula (4) to constitute the compound having a phenol substituent of the formula (1), and the compound of the formula (5) can also react with all of the hydrogen atoms of hydroxyl groups contained in the formula (4) to constitute the compound having a phenol substituent of the formula (1).

The proportions of use of the compound represented by the formula (4) and the compound represented by the formula (5) used in the esterification reaction can be appropriately adjusted according to the number of n_2 .

The esterification reaction can be carried out in the presence of a solvent, with a coupling agent added thereto.

The solvent can be any solvent as long as it can be used in an esterification

reaction.

Specifically, any one solvent selected from the group consisting of dichloromethane (MC, CH_2Cl_2), chloroform (CHCl_3), dimethylformamide (DMF), tetrahydrofuran (THF), dimethylsulfoxide (DMSO) and combinations thereof, can be
5 used.

Examples of the coupling agent that can be used include 4-dimethylaminopyridine (DMAP), carbodiimide compounds (compounds containing the moiety " $-\text{HN}=\text{C}=\text{NH}-$ " in the molecule), and the like.

Preferably, any one selected from the group consisting of
10 N-(3-dimethylaminopropyl)-N'-ethylcarbodiimide (EDCI),
N,N-dicyclohexylcarbodiimide (DCC), N,N'-diphenylcarbodiimide,
N,N'-di-tert-butylcarbodiimide, N,N'-diisopropylcarbodiimide,
1,3-di-p-tolylcarbodiimide, 4-dimethylaminopyridine (DMAP) and combinations thereof
can be used as the coupling agent.

15 The coupling agent can be used at a molar proportion of 0.20 to 1.3, and preferably at a molar proportion of 0.25 to 0.5, based on the compound represented by the formula (5). When the coupling agent is used at a proportion in the range, it can be advantageous in the purification carried out after the esterification reaction.

Furthermore, the esterification reaction can be carried out in the presence of a
20 solvent, with a tertiary amine added thereto.

The tertiary amine may be any one selected from the group consisting of trimethylamine, triethylamine, N,N-diethylpropan-2-amine, N-ethyl-N-isopropylpropan-2-amine, N-ethyl-N-isopropylbutan-2-amine, N-isopropyl-N-propylpropan-2-amine, pyridine, 1-methylpiperidine and combinations
25 thereof, and preferably, triethylamine can be used. However, the tertiary amine is not

limited thereto.

The yield of the esterification reaction can be increased when the reaction is carried out at a temperature of 15°C to 80°C for 6 to 48 hours.

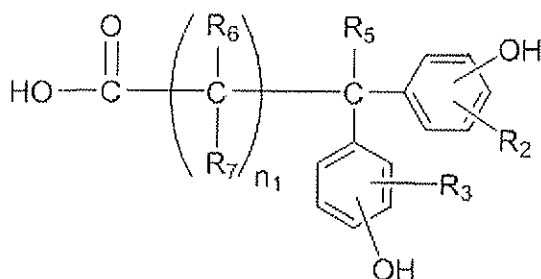
The method for producing the compound having a phenol substituent can further
5 include concentration and purification processes.

The concentration and purification processes can be carried out by any conventional concentration and purification methods used in general compound productions, and the processes may preferably include extracting the produced compound with dichloromethane, drying the extract to form a reaction concentrate, and
10 purifying the reaction concentrate using a silica column.

The compound represented by the formula (5) is produced by stirring a compound represented by the following formula (6) together with a solvent to produce a reaction mixture liquid, and adding a compound selected from the group consisting of a compound of the following formula (7a), a compound of the following formula (7b) and
15 a combination thereof, to the reaction mixture liquid to react.

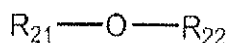
The reaction may also be carried out by further adding a coupling agent into the reaction mixture liquid. The reaction may also be carried out by further adding a tertiary amine into the reaction mixture liquid.

[Formula 6]



wherein n_1 , R_2 , R_3 , R_5 , R_6 and R_7 have the same meanings as defined above.

[Formula 7a]



[Formula 7b]



5 wherein in the formula (7a) and formula (7b), X_2 is any one selected from the group consisting of a hydrogen atom and a halogen atom; and R_{21} , R_{22} and R_{23} are each independently an acid-dissociable functional group.

R_{21} , R_{22} and R_{23} may be preferably each any one selected from the group consisting of the compound of formula (3a) and the compound of formula (3b), and more
10 preferably any one selected from the group consisting of the compounds of formula (3a-1) to formula (3a-9), and the compounds of formula (3b-1) to formula (3b-13).

For the solvent, any one selected from the group consisting of water, tetrahydrofuran (THF), dichloromethane (MC, CH_2Cl_2), chloroform ($CHCl_3$), dimethylformamide (DMF), dimethylsulfoxide (DMSO), and combinations thereof, can
15 be used.

Examples of the coupling agent include 4-dimethylaminopyridine (DMAP), carbodiimide compounds (compounds containing the moiety " $-HN=C=NH-$ " in the molecule), and the like.

Preferably, any one selected from the group consisting of
20 N-(3-dimethylaminopropyl)-N'-ethylcarbodiimide (EDCI),
N,N-dicyclohexylcarbodiimide (DCC), N,N'-diphenylcarbodiimide,
N,N'-di-tert-butylcarbodiimide, N,N'-diisopropylcarbodiimide,
1,3-di-p-tolylcarbodiimide, 4-dimethylaminopyridine (DMAP) and combinations thereof
can be used as the coupling agent, and preferably, 4-dimethylaminopyridine (DMAP) can
25 be used. However, the coupling agent is not limited to these.

The tertiary amine can be any one selected from the group consisting of trimethylamine, triethylamine, N,N-diethylpropan-2-amine, N-ethyl-N-isopropylpropan-2-amine, N-ethyl-N-isopropylbutan-2-amine, N-isopropyl-N-propylpropan-2-amine, pyridine, 1-methylpiperidine and combinations thereof, and preferably, triethylamine can be used. However, the tertiary amine is not limited to these.

It is preferable to carry out the reaction that produces the compound represented by the formula (5) at a temperature of 0°C to 50°C for 3 to 10 hours, from the viewpoint of reducing the generation of impurities.

The reaction that produces the compound represented by the formula (5) can further include concentration and purification processes. The concentration and purification processes can be carried out by any conventional concentration and purification methods used in general compound production, and the processes may preferably include extracting the produced compound with dichloromethane, drying the extract to form a reaction concentrate, and purifying the reaction concentrate using a silica column.

The method for producing the phenol compound is advantageously effective in view of being capable of producing the compound having a phenol substituent represented by the formula (2) at a high yield, using an esterification reaction.

According to another embodiment of the present invention, there is provided a resist composition containing the compound having a phenol substituent and a photoacid generator. The resist composition can be produced by mixing the compound having a phenol substituent, a photoacid generator and additives in a solvent.

As the compound having a phenol substituent, the compound having the phenol substituent represented by the formula (1) is used.

The photoacid generator can be any compound as long as it can be used as a photoacid generator for chemically amplified type resists. The photoacid generator can be any one selected from the group consisting of onium salt-based photoacid generators such as iodonium salts and sulfonium salts, oxime sulfonate-based photoacid generators, 5 diazomethane-based photoacid generators, nitrobenzyl sulfonate-based photoacid generators, iminosulfonate-based photoacid generators, disulfone-based photoacid generators and combinations thereof.

Specific examples of the onium salt-based photoacid generators include

	diphenyliodonium	trifluoromethanesulfonate,	diphenyliodonium
10	nonafluorobutanesulfonate,	bis(4-t-butylphenyl)iodonium	trifluoromethanesulfonate,
	bis(4-t-butylphenyl)iodonium	nonafluorobutanesulfonate,	triphenylsulfonium
	trifluoromethanesulfonate,	triphenylsulfonium	heptafluoropropanesulfonate,
	triphenylsulfonium	nonafluorobutanesulfonate,	tri(4-methylphenyl)sulfonium
	trifluoromethanesulfonate,	tri(4-methylphenyl)sulfonium	heptafluoropropanesulfonate,
15	tri(4-methylphenyl)sulfonium		nonafluorobutanesulfonate,
	dimethyl(4-hydroxynaphthyl)sulfonium		trifluoromethanesulfonate,
	dimethyl(4-hydroxynaphthyl)sulfonium		heptafluoropropanesulfonate,
	dimethyl(4-hydroxynaphthyl)sulfonium		nonafluorobutanesulfonate,
	monophenyldimethylsulfonium		trifluoromethanesulfonate,
20	monophenyldimethylsulfonium		heptafluoropropanesulfonate,
	monophenyldimethylsulfonium		nonafluorobutanesulfonate,
	diphenylmonomethylsulfonium		trifluoromethanesulfonate,
	diphenylmonomethylsulfonium		heptafluoropropanesulfonate,
	diphenylmonomethylsulfonium		nonafluorobutanesulfonate,
25	(4-methylphenyl)diphenylsulfonium		trifluoromethanesulfonate,

	(4-methylphenyl)diphenylsulfonium	heptafluoropropanesulfonate,
	(4-methylphenyl)diphenylsulfonium	nonafluorobutanesulfonate,
	(4-methoxyphenyl)diphenylsulfonium	trifluoromethanesulfonate,
	(4-methoxyphenyl)diphenylsulfonium	heptafluoropropanesulfonate,
5	(4-methoxyphenyl)diphenylsulfonium	nonafluorobutanesulfonate,
	tri(4-tert-butyl)phenylsulfonium	trifluoromethanesulfonate,
	tri(4-tert-butyl)phenylsulfonium	heptafluoropropanesulfonate,
	tri(4-tert-butyl)phenylsulfonium nonafluorobutanesulfonate, and the like.	

Specific examples of the oxime sulfonate-based photoacid generators include

10	α -(p-toluenesulfonyloxyimino)benzyl	cyanide,
	α -(4-nitrobenzenesulfonyloxyimino)benzyl	cyanide,
	α -(4-nitro-2-trifluoromethylbenzenesulfonyloxyimino)benzyl	cyanide,
	α -(benzenesulfonyloxyimino)-4-chlorobenzyl	cyanide,
	α -(benzenesulfonyloxyimino)-2,4-dichlorobenzyl	cyanide,
15	α -(benzenesulfonyloxyimino)-2,6-dichlorobenzyl	cyanide,
	α -(benzenesulfonyloxyimino)-4-methoxybenzyl	cyanide,
	α -(2-chlorobenzenesulfonyloxyimino)-4-methoxybenzyl	cyanide,
	α -(benzenesulfonyloxyimino)-thien-2-yl	acetonitrile,
	α -(4-dodecylbenzenesulfonyloxyimino)benzyl	cyanide,
20	α -[(p-toluenesulfonyloxyimino)-4-methoxyphenyl]acetonitrile,	
	α -[(dodecylbenzenesulfonyloxyimino)-4-methoxyphenyl]acetonitrile,	
	α -(tosyloxyimino)-4-thienyl	cyanide,
	α -(methylsulfonyloxyimino)-1-cyclopentenylacetonitrile,	
	α -(methylsulfonyloxyimino)-1-cyclohexenylacetonitrile,	

- α -(methylsulfonyloxyimino)-1-cycloheptenylacetonitrile,
 α -(methylsulfonyloxyimino)-1-cyclooctenylacetonitrile,
 α -(trifluoromethylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
 α -(trifluoromethylsulfonyloxyimino)-cyclohexylacetonitrile,
5 α -(ethylsulfonyloxyimino)-ethylacetonitrile,
 α -(propylsulfonyloxyimino)-propylacetonitrile,
 α -(cyclohexylsulfonyloxyimino)-cyclopentylacetonitrile,
 α -(cyclohexylsulfonyloxyimino)-cyclohexylacetonitrile,
 α -(cyclohexylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
10 α -(ethylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
 α -(isopropylsulfonyloxyimino)-1-cyclopentenylacetonitrile,
 α -(n-butylsulfonyloxyimino)-1-cyclopentenylacetonitrile, α -
(ethylsulfonyloxyimino)-1-cyclohexenylacetonitrile,
 α -(isopropylsulfonyloxyimino)-1-cyclohexenylacetonitrile, α -
15 (n-butylsulfonyloxyimino)-1-cyclohexenylacetonitrile,
 α -(methylsulfonyloxyimino)-phenylacetonitrile,
 α -(methylsulfonyloxyimino)-p-methoxyphenylacetonitrile,
 α -(trifluoromethylsulfonyloxyimino)-phenylacetonitrile,
 α -(trifluoromethylsulfonyloxyimino)-p-methoxyphenylacetonitrile,
20 α -(ethylsulfonyloxyimino)-p-methoxyphenylacetonitrile,
 α -(propylsulfonyloxyimino)-p-methylphenylacetonitrile,
 α -(methylsulfonyloxyimino)-p-bromophenylacetonitrile, and the like.

As the diazomethane-based photoacid generators,

bisalkylsulfonyldiazomethanes, bisarylsulfonyldiazomethanes, poly(bissulfonyl)diazomethanes and the like. Specific examples of the bisalkyl- or bisarylsulfonyldiazomethanes include bis(isopropylsulfonyl)diazomethane, bis(p-toluenesulfonyl)diazomethane, bis(1,1-dimethylethylsulfonyl)diazomethane, bis(cyclohexylsulfonyl)diazomethane, bis(2,4-dimethylphenylsulfonyl)diazomethane and the like. Specific examples of the poly(bissulfonyl)diazomethanes that can be used include 1,3-bis(phenylsulfonyldiazomethylsulfonyl)propane, 1,4-bis(phenylsulfonyldiazomethylsulfonyl)butane, 1,6-bis(phenylsulfonyldiazomethylsulfonyl)hexane, 1,10-bis(phenylsulfonyldiazomethylsulfonyl)decane, 1,2-bis(cyclohexylsulfonyldiazomethylsulfonyl)ethane, 1,3-bis(cyclohexylsulfonyldiazomethylsulfonyl)propane, 1,6-bis(cyclohexylsulfonyldiazomethylsulfonyl)hexane, 1,10-bis(cyclohexylsulfonyldiazomethylsulfonyl)decane, and the like.

The photoacid generator can be used after adjusting the amount appropriately in accordance with the exposure energy of the light source, the properties of the resist composition, and the like.

When the compound having a phenol substituent is incorporated into a resist composition together with the photoacid generator, the acid-dissociable functional group is dissociated by the acid generated from the photoacid generator as a result of exposure, and thereby the solubility of the exposed part increases so that there occurs a difference in the solubility at the unexposed part. Due to such characteristics, the resist composition can be used particularly as a positive type resist composition.

For the solvent, conventional solvents that are used in resist compositions can be used, and specifically, any one selected from the group consisting of alcohol-based

solvents, ether-based solvents, ester-based solvents, acetate-based solvents, aromatic hydrocarbon-based solvents, amide-based solvents, halogenated hydrocarbon-based solvents and combinations thereof, can be used.

Examples of the alcohol-based solvents include polyhydric alcohols and
5 derivatives thereof, such as monomethyl ether, monoethyl ether, monopropyl ether, monobutyl ether and monophenyl ether of ethylene glycol, ethylene glycol monoacetate, diethylene glycol, diethylene glycol monoacetate, propylene glycol, propylene glycol monoacetate, dipropylene glycol and dipropylene glycol monoacetate. Examples of the ether-based solvents include cyclic ethers such as dioxane; propylene glycol monoalkyl
10 ethers such as propylene glycol monomethyl ether, propylene glycol monoethyl ether, propylene glycol mono-n-propyl ether, and propylene glycol mono-n-butyl ether; and the like. Examples of the ester-based solvents include lactic acid esters such as methyl lactate, ethyl lactate, n-propyl lactate and i-propyl lactate; aliphatic carboxylic acid esters such as n-amyl formate, i-amyl formate, ethyl acetate, n-propyl acetate, i-propyl acetate,
15 n-butyl acetate, i-butyl acetate, n-amyl acetate, i-amyl acetate, i-propyl propionate, n-butyl propionate and i-butyl propionate; and other esters such as ethyl hydroxyacetate, ethyl 2-hydroxy-2-methylpropionate, methyl 2-hydroxy-3-methylbutyrate, ethyl methoxyacetate, ethyl ethoxyacetate, methyl 3-methoxypropionate, ethyl 3-methoxypropionate, methyl 3-ethoxypropionate, ethyl 3-ethoxypropionate,
20 3-methoxybutyl acetate, 3-methyl-3-methoxybutyl acetate, 3-methyl-3-methoxybutyl propionate, 3-methyl-3-methoxybutyl butyrate, methyl acetoacetate, ethyl acetoacetate, methyl pyruvate and ethyl pyruvate, and esters such as methyl lactate, ethyl lactate (EL), methyl acetate, ethyl acetate, butyl acetate, methyl pyruvate, ethyl pyruvate, methyl methoxypropionate and ethyl ethoxypropionate can also be used. Examples of the
25 acetate-based solvents include ethylene glycol monoalkyl ether acetates such as ethylene

glycol monomethyl ether acetate, ethylene glycol monoethyl ether acetate, ethylene glycol mono-n-propyl ether acetate and ethylene glycol mono-n-butyl ether acetate; propylene glycol monoalkyl ether acetates such as propylene glycol monomethyl ether acetate, propylene glycol monoethyl ether acetate, propylene glycol mono-n-propyl ether acetate and propylene glycol mono-n-butyl ether acetate; and the like. Examples of the aromatic hydrocarbon-based solvents include toluene, xylene and the like. Examples of the amide-based solvents such as N-methylformamide, N,N-dimethylformamide, N-methylacetamide, N,N-dimethylacetamide, and N-methylpyrrolidone and the like. In addition to these, ketones such as acetone, methyl ethyl ketone, methyl propyl ketone, methyl butyl ketone, 2-heptanone, 3-heptanone, 4-heptanone, cyclohexanone and methyl isoamyl ketone; lactones such as γ -butyrolactone; and the like can be used.

Examples of the additives include an acid diffusion suppressing agent, a dissolution suppressing agent, a surfactant, a sensitizer, an aliphatic additive, an alkali-soluble resin, a storage stabilizer, a defoamer, and the like, and any additives that are used in resist compositions can be used.

As the acid diffusion suppressing agent, a nitrogen-containing organic compound or a photosensitive basic compound can be used. Examples of the nitrogen-containing organic compound include an amide group-containing compound, a urea compound, a compound having one or two or more nitrogen atoms in a same molecule, and the like.

Specific examples thereof include mono(cyclo)alkylamines such as n-hexylamine, n-heptylamine, n-octylamine, n-nonylamine, n-decylamine and cyclohexylamine; di(cyclo)alkylamines such as di-n-butylamine, di-n-pentylamine, di-n-hexylamine, di-n-heptylamine, di-n-octylamine, di-n-nonylamine, di-n-decylamine, cyclohexylmethylamine and dicyclohexylamine; tri(cyclo)alkylamines such as

triethylamine, tri-n-propylamine, tri-n-butylamine, tri-n-pentylamine, tri-n-hexylamine, tri-n-heptylamine, tri-n-octylamine, tri-n-nonylamine, tri-n-decylamine, cyclohexyldimethylamine, methyldicyclohexylamine and tricyclohexylamine; substituted alkylamines such as triethanolamine; aromatic amines such as aniline, N-methylaniline, N,N-dimethylaniline, 2-methylaniline, 3-methylaniline, 4-methylaniline, 4-nitroaniline, diphenylamine, triphenylamine, naphthylamine, 2,4,6-tri-tert-butyl-N-methylaniline, N-phenyldiethanolamine and 2,6-diisopropylaniline; ethylenediamine, N,N,N',N'-tetramethylethylenediamine, tetramethylenediamine, hexamethylenediamine, 4,4'-diaminodiphenylmethane, 4,4'-diaminodiphenyl ether, 4,4'-diaminobenzophenone, 4,4'-diaminodiphenylamine, 2,2-bis(4-aminophenyl)propane, 2-(3-aminophenyl)-2-(4-aminophenyl)propane, 2-(4-aminophenyl)-2-(3-hydroxyphenyl)propane, 2-(4-aminophenyl)-2-(4-hydroxyphenyl)propane, 1,4-bis[1-(4-aminophenyl)-1-methylethyl]benzene, 1,3-bis[1-(4-aminophenyl)-1-methylethyl]benzene, bis(2-dimethylaminoethyl)ether, bis(2-diethylaminoethyl)ether, 1-(2-hydroxyethyl)-2-imidazolidinone, 2-quinoxalinol, N,N,N',N'-tetrakis(2-hydroxypropyl)ethylenediamine, N,N,N',N'',N''-pentamethyldiethylenetriamine, and the like.

The acid diffusion suppressing agent has an action of controlling the phenomenon that the acid generated from the photoacid generator diffuses within a film formed from a resist composition, and thereby suppressing a chemical reaction extending to non-exposed parts. Such an acid diffusion suppressing agent can also contribute to an enhancement of storage stability. Furthermore, changes in the line width of a resist pattern due to the delay time after exposure can be suppressed.

In regard to the surfactant, any surfactant that is generally used in resist

compositions can be used.

Specifically, any one selected from the group consisting of polyoxyethylene lauryl ether, polyoxyethylene stearyl ether, polyoxyethylene oleyl ether, polyoxyethylene n-octylphenol ether, polyoxyethylene n-nonylphenol ether, polyethylene glycol dilaurate, polyethylene glycol distearate and combinations thereof can be used.

As the sensitizer, any one selected from the group consisting of carbazoles, acetophenones, benzophenones, naphthalenes, phenols, biacetyl, eosin, Rose Bengal, pyrenes, anthracenes, phenothiazines and combinations thereof can be used.

The resist composition is formed into a resist in a film form by using any conventional method used in the formation of resist films, can be used in the photoresist processes as a photosensitive resist composition, and is particularly useful as a positive type resist composition.

The method of forming a pattern with the resist composition includes a process of forming a resist film on a substrate using the resist composition, a process of exposing the resist film, and a process of forming a resist pattern by developing the resist film.

In the process of forming a resist film, when the resist composition is solid, a composition which has been filtered through a filter having a pore size of 0.2 μm or less can be used. The resist composition is applied on a substrate by an appropriate application means such as rotational application, flow casting application, or roll application. The substrate may be a substrate such as a silicon wafer or a wafer coated with aluminum. The substrate may have an organic or inorganic reflection preventive film formed thereon, or may have a protective film formed on the resist film. Also, a preheating treatment (PB) can be carried out selectively.

As the light source that is used in the process of exposing the resist film, any light source that may be generally used in exposure processes can be used without

particular limitation, but radiations such as ArF excimer laser light, KrF excimer laser light, F2 excimer laser light, EUV, vacuum ultraviolet (VUV), electron beam and X-rays can be used as light sources. As for the light source, it is preferable to use electron beam or EUV, and it is particularly preferable to use EUV. The exposure conditions
5 such as the exposure dose can be appropriately regulated according to the blend of the resist composition, or the type or amount of additives. The exposure can also be carried out in the liquid immersion exposure mode.

The process of exposing the resist film can further include a process of heat treating (PEB) after exposure. The PEB process can accelerate detachment of the
10 acid-dissociable group of the compound having a phenol substituent. The heating conditions for the PEB process can be appropriately controlled according to the blend composition of the resist composition. The heating conditions may be preferably 30°C to 200°C, and more preferably 50°C to 170°C.

In regard to the alkali developing liquid to be used, any alkali developing liquid
15 used as a resist developing liquid can be used without any particular limitation. Specifically, the alkali developing liquid may be an alkali aqueous solution formed by dissolving an organic alkali such as tetramethylammonium hydroxide (TMAH), trimethylmonoethylammonium hydroxide, dimethyldiethylammonium hydroxide, monomethyltriethylammonium hydroxide, trimethylmonopropylammonium hydroxide or
20 trimethylmonobutylammonium hydroxide, in water.

The alkali concentration in the alkali developing liquid is not particularly limited as long as it is a concentration that can be generally used as a developing liquid, and can be appropriately regulated according to the type of the resist. From the viewpoint of forming a very fine pattern while suppressing the disintegration of pattern, the alkali
25 concentration in the alkali developing liquid is preferably 0.1 to 10% by mass, and more

preferably 0.5 to 5% by mass.

The alkali developing liquid can further include, if necessary, those additives used in the alkali developing liquids for conventional resists, for example, a wetting agent, a stabilizer, a dissolution aid, a surfactant and the like. These additives can be
5 included singly or in combination of two or more kinds.

The resist can be developed with the alkali developing liquid, and then can be washed with pure water and dried.

Since the resist composition makes use of the compound having a phenol substituent of the present invention, which has high heat resistance and amorphousness,
10 the resist composition is excellent in film formability, alkali developability and etching resistance.

The resist composition can be exposed using light sources such as g-rays and i-rays, as well as ultraviolet radiation, KrF excimer laser light, ArF excimer laser light, EUV, X-radiation and electron beam, and the resist composition is particularly useful for
15 an EUV light source for forming ultrafine patterns.

Simple alterations or modifications of the present invention can be easily made by those having ordinary skill in the art, and such alterations or modifications are understood to be included in the scope of the present invention.

Since the compound having a phenol substituent of the present invention has
20 high heat resistance and amorphousness, the compound has film formability and sublimability so that the compound is useful as a main component for resist compositions. Furthermore, the method for producing the compound having a phenol substituent of the present invention can be used to produce the compound having a phenol substituent at a high yield.

25 A resist composition containing the compound having a phenol substituent is

excellent in film formability and is also excellent in alkali developability and etching resistance. Particularly, the resist composition can be usefully used in lithography where an EUV light source is used for the formation of ultrafine patterns, and the patterns formed using the resist composition are excellent in all of sensitivity, resolution
5 and line edge roughness.

EXAMPLES

Hereinafter, Examples of the present invention will be described in detail so that those having ordinary skill in the art can easily carry out the present invention.

10 However, the invention can be realized in various different forms, and is not limited only to the Examples explained herein.

[Synthesis Example: Production of compound having phenol substituent]

(Synthesis Example 1)

50 g of 4,4-bis(4-hydroxyphenyl)valeric acid, 50 g of triethylamine (Et_3N) and
15 10.7 g of 4-dimethylaminopyridine (DMAP) were dissolved in 250 ml of tetrahydrofuran (THF) and 250 ml of water in a reactor, and the mixture was stirred.

107 g of di-tert-butyl dicarbonate ($(\text{Boc})_2\text{O}$) was dissolved in 250 ml of tetrahydrofuran (THF), and the solution was slowly added dropwise to the reaction mixture liquid. The resulting mixture was allowed to react under stirring for 5 hours at
20 ambient temperature.

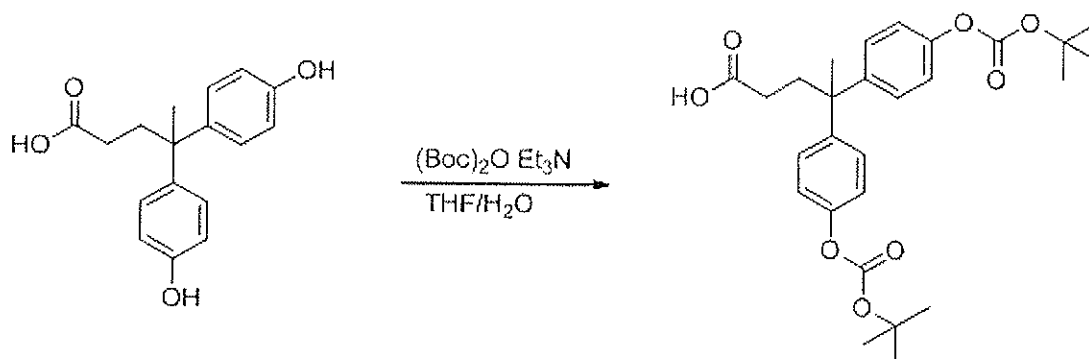
When the reaction was completed, the organic solvent was removed, and then the residue was dissolved in dichloromethane. The solution was subjected to extraction, washing with a 1% aqueous solution of hydrochloric acid (HCl), drying over magnesium sulfate (MgSO_4), and then to filtration and concentration.

25 The reaction concentrate was purified using a silica column (Hex/EA = 3:1), and

thus 76.2 g (yield: 90%) of 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid was obtained as a white solid.

$^1\text{H-NMR}$ (DMSO-d_6): (ppm) 7.35(d, 4H), 7.16(d, 4H), 2.48(m, 2H) 2.12(m, 2H), 1.68(s, 3H), 1.51(s, 18H)

5 [Reaction Scheme 1]



(Example 1)

18 g of 1,3-propanediol was dissolved in 200 ml of dimethylformamide (DMF) in a reactor, and 253 g of 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid produced in the Synthesis Example 1 and 500 ml of dichloromethane were added dropwise to the solution. 58 g of DMAP was added to the reaction mixture liquid, and 100g of 3-(methylamino)propylethyl carbodiimide hydrochloride (EDCI) dissolved in 500 ml of dichloromethane was added dropwise to the reaction mixture liquid. Then, the resulting mixture was stirred for 12 hours at ambient temperature.

15 After the reaction was completed, 500 ml of dichloromethane was added to the mixture, and the mixture was washed three times with a 1% aqueous solution of hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate (Na_2SO_4) and concentrated.

20 The reaction concentrate was purified using a silica column (Hex/EA = 1:4), and thus 194 g (yield: 80%) of a substance represented by the following formula (8) was

obtained as a white solid.

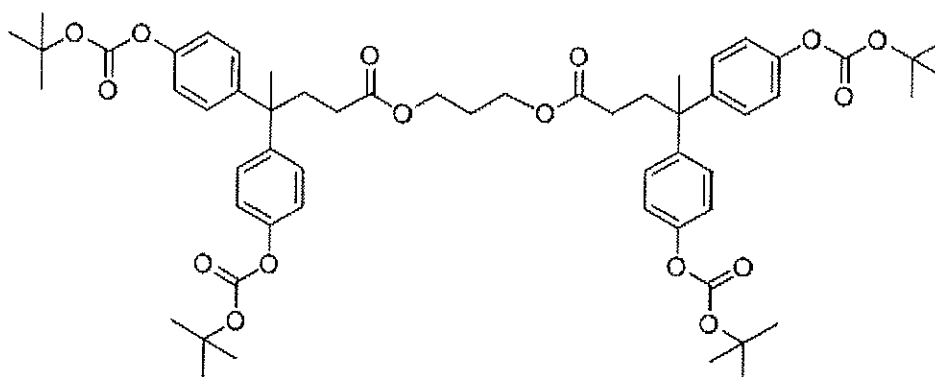
T_m: 151°C, T_g: 47.4°C

Mass analysis: MALDI-TOF calculated for C₅₇H₇₂O₁₆ [M⁺H⁺] 1012.17

¹H-NMR (CDCl₃): (ppm) 7.19(d, 8H), 7.05(d, 8H), 4.05(t, 4H), 2.42(m, 4H),

5 2.09(m, 4H), 1.77(q, 2H), 1.60(s, 6H), 1.55(s, 36H)

[Formula 8]



(Example 2)

5 g of pentaerythritol was dissolved in 100 ml of DMF in a reactor, and 78.6 g of
 10 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid produced in the Synthesis
 Example 1 and 400 ml of dichloromethane were added dropwise to the solution. 3.9 g
 of DMAP was added to the reaction mixture liquid, and 31 g of EDCI dissolved in 400
 ml of dichloromethane was added dropwise thereto. Then, the resulting mixture was
 stirred for 12 hours at ambient temperature.

15 After the reaction was completed, 400 ml of dichloromethane was added to the
 mixture, and the mixture was washed three times with a 1% aqueous solution of
 hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate
 (Na₂SO₄) and concentrated.

The reaction concentrate was purified using a silica column (Hex/EA = 1:3), and
 20 thus 57.3 g (yield: 77%) of a substance represented by the following formula (9) was

obtained as a white solid.

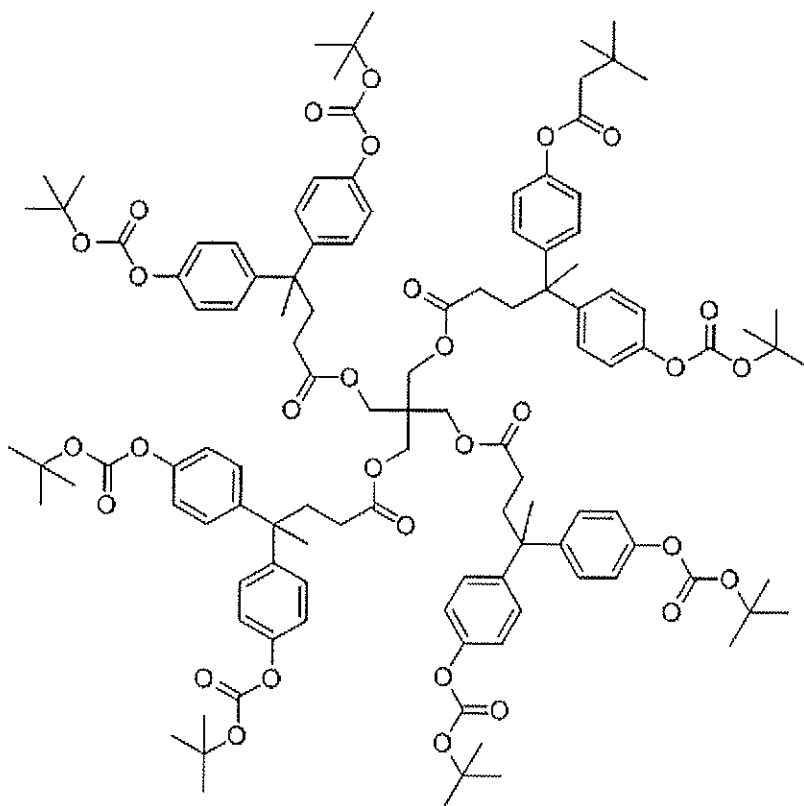
Tm: 85°C, Tg: 70.1°C

Mass analysis: MALDI-TOF calculated for $C_{114}H_{142}O_{31}$ [M^+H^+] 2007.33

1H -NMR ($CDCl_3$): (ppm) 7.19(d, 16H), 7.05(d, 16H), 3.95(s, 8H), 2.38(m, 8H),

5 2.04(m, 8H), 1.58(s, 12H), 1.76(s, 72H)

[Formula 9]



(Example 3)

20

g

of

dipentaerythritol

10 (2,2'-oxybis(methylene)bis(2-(hydroxymethyl)propane-1,3-diol) was dissolved in 200 ml of DMF in a reactor, and 253 g of 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid produced in the Synthesis Example 1 and 600 ml of dichloromethane were added dropwise thereto. 29 g of DMAP was added to the reaction mixture liquid, and 100 g of EDCI dissolved in 600 ml of dichloromethane was added dropwise thereto. Then, the

resulting mixture was stirred for 12 hours at ambient temperature.

After the reaction was completed, 600 ml of dichloromethane was added to the mixture, and the mixture was washed three times with a 1% aqueous solution of hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate
5 (Na₂SO₄) and concentrated.

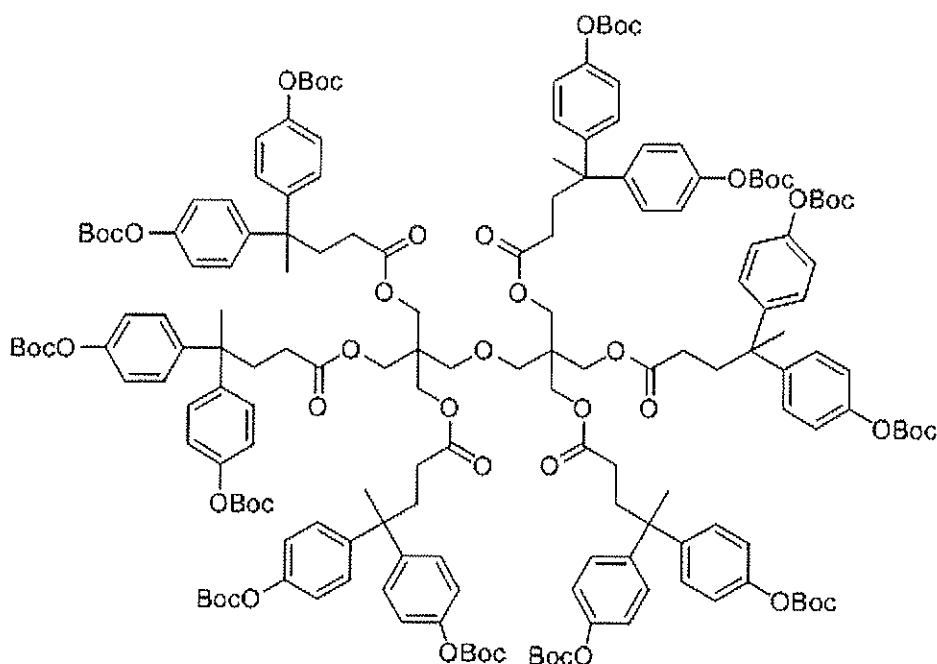
The reaction concentrate was purified using a silica column (Hex/EA = 1:3), and thus 185.5 g (yield: 77%) of a substance represented by the following formula (10) was obtained as a white solid.

T_m: 100°C, T_g: 74.1°C

10 Mass analysis: HRMS (ESI) calculated for C₁₇₂H₂₁₄O₄₉ [M⁺H⁺] 3064.51

¹H-NMR (D₂O): (ppm) 7.18(d, 24H), 7.05(d, 24H), 3.92(s, 12H), 3.25(s, 4H), 2.38(m, 12H), 2.06(m, 12H), 1.58(s, 18H), 1.56(s, 108H)

[Formula 10]



15 wherein Boc means a tert-butyloxycarbonyl group.

(Example 4)

38 g of 1,4-benzendimethanol was dissolved in 300 ml of DMF in a reactor, and 294 g of 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid produced in the Synthesis Example 1 and 600 ml of dichloromethane were added dropwise thereto. 67 g of DMAP was added to the reaction mixture liquid, and 116 g of EDCI dissolved in 600 ml of dichloromethane was added dropwise thereto. The resulting mixture was stirred for 12 hours at ambient temperature.

After the reaction was completed, 600 ml of dichloromethane was added to the mixture, and the mixture was washed three times with a 1% aqueous solution of hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate (Na_2SO_4) and concentrated.

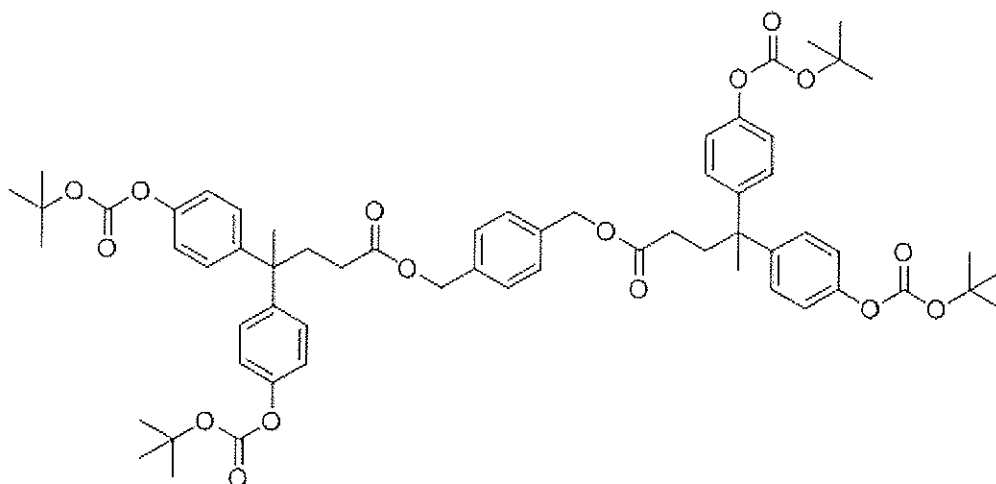
The reaction concentrate was purified using a silica column (Hex/EA = 1:3), and thus 242.5 g (yield: 82%) of a substance represented by the following formula (11) was obtained as a white solid.

Tm: 170°C, Tg: ND

Mass analysis: MALDI-TOF calculated for $\text{C}_{62}\text{H}_{74}\text{O}_{16}$ [M^+H^+] 1074.24

^1H -NMR (CDCl_3): (ppm) 7.35(s, 4H), 7.19(d, 8H), 7.05(d, 8H), 4.05(s, 4H), 2.42(m, 4H), 2.09(m, 4H), 1.60(s, 6H), 1.55(s, 36H)

[Formula 11]



(Example 5)

40 g of phloroglucinol (benzene-1,3,5-triol) was dissolved in 300 ml of DMF in a reactor, and 509 g of 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid produced in the Synthesis Example 1 and 600 ml of dichloromethane were added dropwise thereto.

5 77 g of DMAP was added to the reaction mixture liquid, and 201 g of EDCI dissolved in 600 ml of dichloromethane was added dropwise thereto. The resulting mixture was stirred for 12 hours at ambient temperature.

After the reaction was completed, 600 ml of dichloromethane was added to the mixture, and the mixture was washed three times with a 1% aqueous solution of
10 hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate (Na_2SO_4) and concentrated.

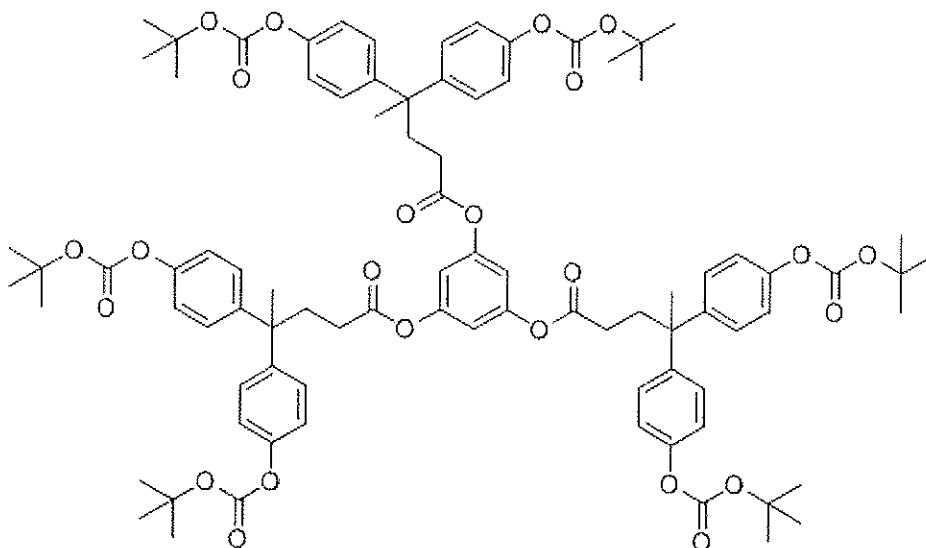
The reaction concentrate was purified using a silica column (Hex/EA = 1:3), and thus 364.2 g (yield: 75%) of a substance represented by the following formula (12) was obtained as a white solid.

15 Tm: 93°C, Tg: 70.5°C

Mass analysis: MALDI-TOF calculated for $\text{C}_{87}\text{H}_{102}\text{O}_{24}$ [M^+H^+] 1530.73

^1H -NMR (CDCl_3): (ppm) 7.12(d, 12H), 7.05(d, 12H), 2.45(m, 6H), 2.15(m, 6H), 1.62(s, 8H), 1.57(s, 27H)

[Formula 12]



(Example 6)

20 g of 2,5-dihydroxydioxane dimer was dissolved in 150 ml of DMF in a reactor, and 128 g of 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid produced in the Synthesis Example 1 and 300 ml of dichloromethane were added dropwise thereto.

27 g of DMAP was added to the reaction mixture liquid, and 97 g of EDCI dissolved in 300 ml of dichloromethane was added dropwise thereto. The resulting mixture was stirred for 12 hours at ambient temperature.

After the reaction was completed, 300 ml of dichloromethane was added to the mixture, and the mixture was washed three times with a 1% aqueous solution of hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate (Na_2SO_4) and concentrated.

The reaction concentrate was purified using a silica column (Hex/EA = 1:3), and thus 175.2 g (yield: 77%) of a substance represented by the following formula (13) was obtained as a white solid.

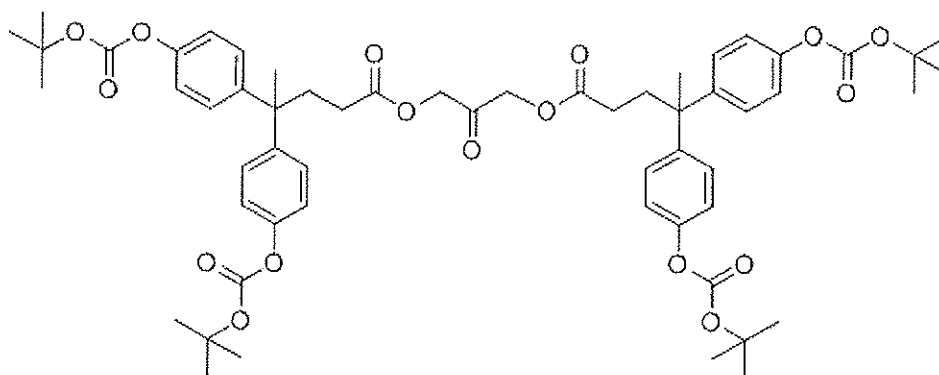
T_m : 72°C, T_g : 45°C

Mass analysis: MALDI-TOF calculated for $\text{C}_{57}\text{H}_{70}\text{O}_{17}$ [M^+H^+] 1026.16

$^1\text{H-NMR}$ (D_2O): (ppm) 7.19(d, 8H), 7.05(d, 8H), 4.62(s, 4H), 2.42(m, 4H),

2.21(m, 4H), 1.60(s, 6H), 1.58(s, 36H)

[Formula 13]



(Synthesis Example 2)

5 50 g (0.18 mol) of 4,4-bis(4-(tert-butoxycarbonyloxy)phenyl)valeric acid, 50 g (0.5 mol) of triethylamine and 10.7 g (0.09 mol) of DMAP were dissolved in 250 ml of tetrahydrofuran and 250 ml of water in a reactor, and the mixture was stirred.

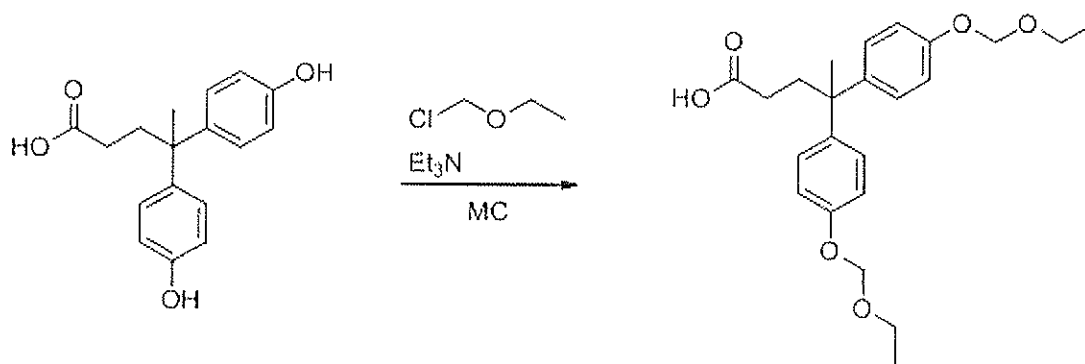
 47 g (0.5 mol) of chloromethyl ethyl ether was dissolved in 250 ml of dichloromethane, and the solution was slowly added dropwise to the reaction mixture
10 liquid. The resulting mixture was stirred for 5 hours at ambient temperature.

 After the reaction was completed, water was added to the mixture to perform extraction, and the mixture was washed three times with a 1% aqueous solution of hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate (Na₂SO₄), filtered and then concentrated.

15 The reaction concentrate was purified using a silica column (Hex/EA = 4:1), and thus 67 g (yield: 92%) of 4,4-bis-(4-ethoxymethoxyphenyl)-pentanoic acid was obtained as a white solid.

¹H-NMR (DMSO-d₆): (ppm) 7.25(d, 4H), 7.06(d, 4H), 6.03(s, 4H), 3.44(q, 4H), 2.43(m, 2H), 2.15(m, 2H), 1.12(t, 6H)

20 [Reaction Scheme 2]



(Example 7)

18 g (0.24 mol) of 1,3-propanediol was dissolved in 200 ml of DMF in a reactor,
and 212.5 g (0.53 mol) of 4,4-bis-(4-ethoxymethoxyphenyl)-pentanoic acid produced in
5 the Synthesis Example 2 and 500 ml of dichloromethane were added dropwise thereto.

58 g (0.47 mol) of DMAP was added to the reaction mixture liquid, and 100 g
(0.52 mol) of EDCI dissolved in 500 ml of dichloromethane was added dropwise thereto.
The resulting mixture was stirred for 12 hours at ambient temperature.

After the reaction was completed, 500 ml of dichloromethane was added to the
10 mixture, and the mixture was washed three times with a 1% aqueous solution of
hydrochloric acid (HCl). Then, the organic layer was dried over sodium sulfate
(Na₂SO₄) and concentrated.

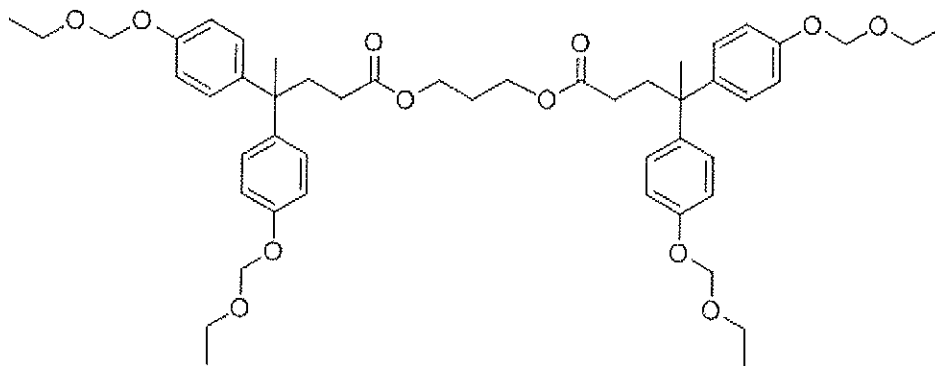
The reaction concentrate was purified using a silica column (Hex/EA = 1:3), and
thus 164.3 g (yield: 81%) of a substance represented by the following formula (14) was
15 obtained as a white solid.

T_m: 141°C, T_g: 45.4°C

Mass analysis: MALDI-TOF calculated for C₅₇H₇₂O₁₆ [M⁺H⁺] 844.03

¹H-NMR (CDCl₃): (ppm) 7.22(d, 8H), 7.07(d, 8H), 6.05(s, 8H), 4.02(t, 4H),
3.42(q, 8H), 2.45(m, 4H), 2.18(m, 4H), 1.82(q, 2H), 1.12(t, 12H)

20 [Formula 14]



[Preparation Example: Formation of resist pattern]

100 parts by weight of the compound having a phenol substituent produced in the Example 1, 5 parts by weight of triphenylsulfonium trifluoromethanesulfonate as a photoacid generator, and 1 part by weight of tri-n-octylamine as an acid diffusion suppressing agent were dissolved in 1500 parts by weight of solvent propylene glycol monoethyl ether acetate, and then the solution was filtered through a membrane filter having a pore size of 0.2 μm to prepare a resist composition.

The compounds having a phenol substituent produced in the Examples 2 to 7 were also respectively treated in the same manner, and thus corresponding resist compositions were prepared.

(Comparative Example 1)

5 parts by weight of a copolymer of 2-Ethyl-2-adamantyl methacrylate and p-hydroxystyrene (ratio of 2-ethyl-2-adamantyl methacrylate/p-hydroxystyrene = 20/80) and 5 parts by weight of a copolymer of 2-ethyl-2-adamantyl methacrylate and p-hydroxystyrene (ratio of 2-ethyl-2-adamantyl methacrylate/p-hydroxystyrene = 30/70), which were synthesized according to the method described in Japanese Patent Application No. 2003-107708, were dissolved in 320 parts by weight of propylene glycol monomethyl ether acetate as a solvent, together with 1 part by weight of tri(4-methylphenyl)(diphenylsulfonium nonafluorobutane sulfonate as a photoacid

generator. Subsequently, the solution was filtered through a membrane filter having a pore size of 0.2 μm , and thus a resist composition was prepared.

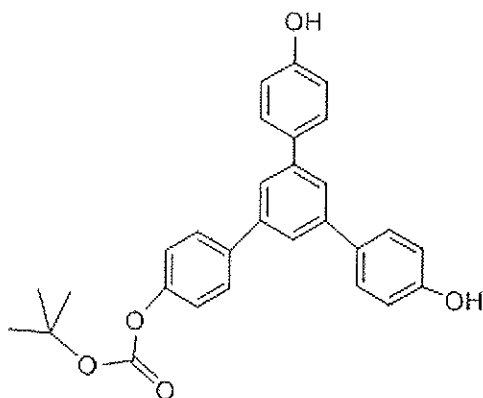
(Comparative Example 2)

3.5 g of 1,3,5-tris(4-hydroxyphenyl)benzene, 1.0 g of triethylamine, and 1.2 g of
5 4-dimethylaminopyridine were dissolved in 200 ml of tetrahydrofuran in a reactor, and the solution was stirred.

2.2 g of di-tert-butyl dicarbonate was dissolved in 20 ml of tetrahydrofuran, and the solution was slowly added dropwise to the reaction mixture liquid. The resulting mixture was stirred for 5 hours at ambient temperature.

10 After the reaction was completed, tetrahydrofuran was distilled off under reduced pressure, and then the residue was extracted with 200 ml of dichloromethane to form an extract. This extract was purified using a silica column, and thus 0.7 g of a compound represented by the following formula (15) was obtained.

[Formula 15]



15

100 parts by weight of the compound represented by the formula (15), 10 parts by weight of triphenylsulfonium trifluoromethanesulfonate as a photoacid generator, and 0.3 parts by weight of tri-n-octylamine as an acid diffusion suppressing agent were dissolved in 1200 parts by weight of ethyl lactate and 600 parts by weight of propylene
20 glycol monoethyl ether acetate, and then the solution was filtered through a membrane

filter having a pore size of 0.2 μm to prepare a resist composition.

(Comparative Example 3)

10 g of polyhydroxystyrene, 5.50 g of di-tert-butyl dicarbonate and 2.80 g of triethylamine were dissolved in a 20% solution of butyl acetate in a reactor, and the
5 solution was stirred for 7 hours at 60°C. Water was added to the reaction liquid, and the mixture was subjected to purification processes. Thus, 12.0 g of a resin containing an acid-dissociable functional group, in which 30% of hydroxyl groups in the polyhydroxystyrene were protected with tert-butyloxycarbonyl, was obtained.

100 parts by weight of the acid-dissociable functional group-containing resin, 9
10 parts by weight of triphenylsulfonium trifluoromethanesulfonate as a photoacid generator, and 1 part by weight of tri-n-octylamine as an acid diffusion suppressing agent were dissolved in 600 parts by weight of ethyl lactate and 1500 parts by weight of propylene glycol monomethyl ether acetate, and the solution was filtered through a membrane filter having a pore size of 0.2 μm to prepare a resist composition.

15 [Experimental Example: Evaluation of properties of produced resist]

Each of the resist compositions prepared in the Examples 1 to 7 and Comparative Examples 1 to 3 was spin coated on a silicon wafer using "Clean Track ACT-8 (trade name)" manufactured by Tokyo Electron, Ltd., and was subjected to a preheating treatment (PB) for 90 seconds at 90°C to form a resist film having a thickness
20 of 100 nm. The resist film was exposed by irradiating the film with an electron beam using a simple type electron beam writing apparatus (HL800D, manufactured by Hitachi Seisakusho, Ltd.; output power 50 KeV, current density: 5.0 A/cm²). After the exposure for 90 seconds at 90°C, the resist film was subjected to a heating treatment (PEB), and then was developed by a paddle method at 23°C for one minute using a 2.38 mass%

aqueous solution of tetramethylammonium hydroxide. The resist film was washed with pure water, and then dried to form a resist pattern.

- Sensitivity: An amount of exposure that forms a line-and-space pattern (1L1S) having a line width of 200 nm at a line width of 1:1 in the formed resist pattern, was designated as the optimum amount of exposure, and this optimum amount of exposure was measured as the sensitivity ($\mu\text{C}/\text{cm}^2$).

- Resolution: The minimum line width at the line part resolved by the optimum amount of exposure in the line-and-space pattern was designated as the resolution.

- LWR (line edge roughness property): Length was measured at arbitrary 30 sites, at the mentioned sensitivity (L/S) and at the line width of the resolution at an interval of 50 μm in the length direction of the line pattern, using a scanning electron microscope for semiconductors (trade name: S-9220 high resolution FEB length analyzer, manufactured by Hitachi Seisakusho, Ltd.). The distribution of the line width fluctuation in the length measurement was calculated by 3σ (nm).

The properties of the resists measured according to the above criteria are presented in the following Table 1.

[Table 1]

	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3
Sensitivity ($\mu\text{C}/\text{cm}^2$)	9	8	10	10	8	8	9	14	14	25
Resolution (nm)	69	64	75	74	63	67	71	90	91	100
Line edge roughness	8	10	6	7	9	8	8	15	14	12

(nm)										
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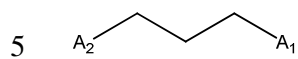
It can be seen that as a result of exposure using an EUV light source, the resist compositions of the Examples 1 to 7 have excellent effects in terms of sensitivity, resolution and line edge roughness as compared with the case of using the resist composition of Comparative Example 2.

5 While preferred embodiments of the invention have been described and illustrated above, it should be understood that these are exemplary of the invention and are not to be considered as limiting. Additions, omissions, substitutions, and other modifications can be made without departing from the spirit or scope of the present invention. Accordingly, the invention is not to be considered as being limited by the
10 foregoing description, and is only limited by the scope of the appended claims.

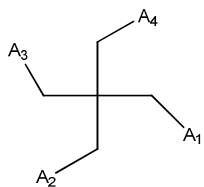
What is claimed is:

1. A compound represented by the following formula (A-1) to formula_(A-6):

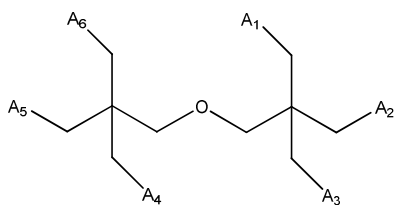
[Formula A-1]



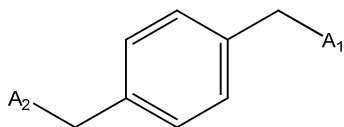
[Formula A-2]



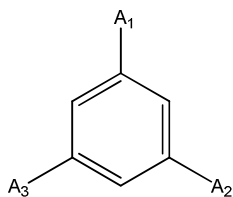
[Formula A-3]



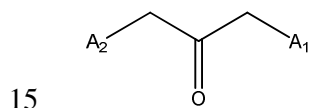
10 [Formula A-4]



[Formula A-5]

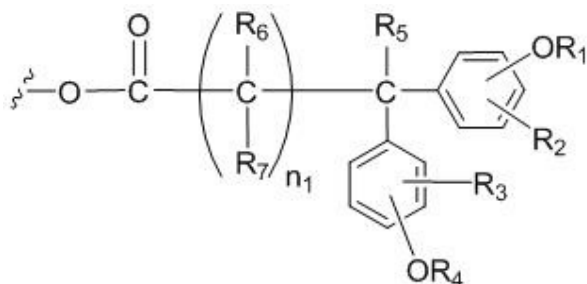


[Formula A-6]



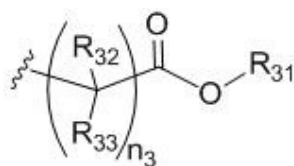
wherein in the formula (A-1) to formula (A-6), A₁ to A₆ are each independently represented by the following formula (1),

[Formula 1]

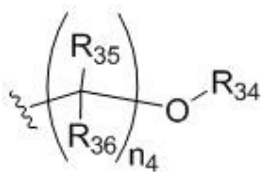


- 5 wherein R₂ and R₃ each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;
- 10 R₅ to R₇ each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a hydroxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;
- 15 n₁ is an integer from 1 to 30; and
- R₁ and R₄ are each independently any one acid-dissociable functional group selected from the group consisting of the following formula (3a) and formula (3b),

[Formula 3a]



[Formula 3b]

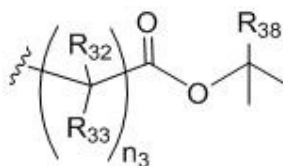


wherein in the formula (3a) and formula (3b), n_3 and n_4 are each independently an integer from 0 to 10;

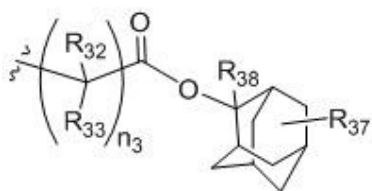
- 5 R_{32} , R_{33} , R_{35} and R_{36} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group; and
- R_{31} and R_{34} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a heteroalkyl group, a cycloalkyl group, a
- 10 heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group.

2. The compound according to claim 1, wherein the substituent represented by the formula (3a) is a substituent represented by any one selected from the group consisting of
- 15 the following formula (3a-1) to formula (3a-9):

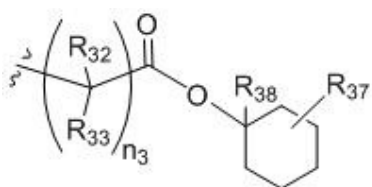
[Formula 3a-1]



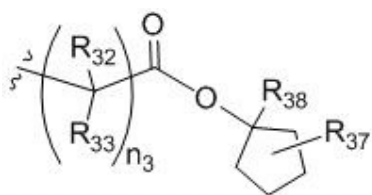
[Formula 3a-2]



[Formula 3a-3]

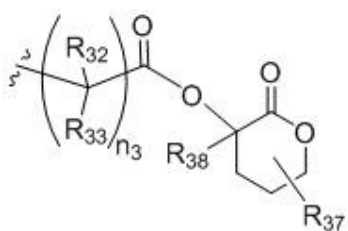


[Formula 3a-4]

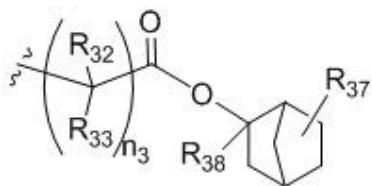


5

[Formula 3a-5]

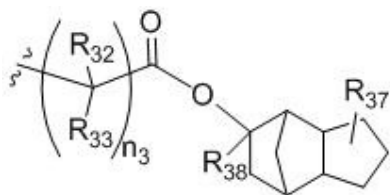


[Formula 3a-6]

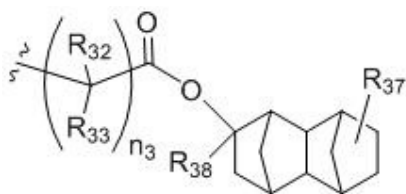


10

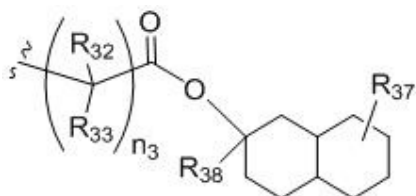
[Formula 3a-7]



[Formula 3a-8]



[Formula 3a-9]



5

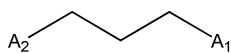
wherein in the formula (3a-1) to formula (3a-9), n_3 is an integer from 0 to 10;

R_{32} and R_{33} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group; and

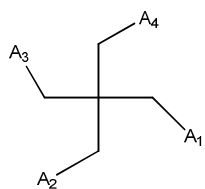
10 R_{37} and R_{38} are each independently any one selected from the group consisting of a hydrogen atom and an alkyl group having 1 to 10 carbon atoms.

3. A resist composition comprising the compound represented by the following formula (A-1) to formula (A-6), and a photoacid generator:

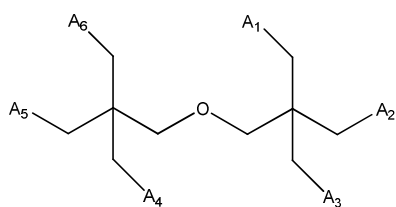
15 [Formula A-1]



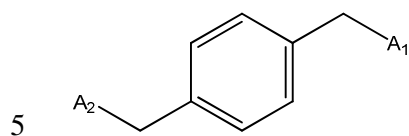
[Formula A-2]



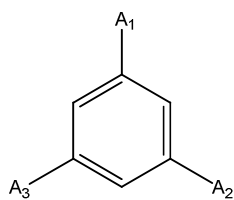
[Formula A-3]



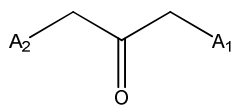
[Formula A-4]



[Formula A-5]

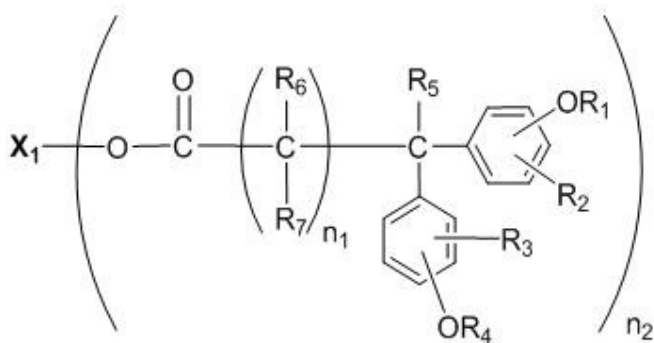


[Formula A-6]



10 wherein in the formula (A-1) to formula (A-6), A₁ to A₆ are each independently represented by the following formula (1),

[Formula 1]



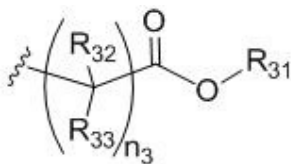
wherein R_2 and R_3 each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;

R_5 to R_7 each independently represent any one selected from the group consisting of a hydrogen atom, a halogen atom, a carboxyl group, a hydroxyl group, a nitrile group, an aldehyde group, an epoxy group, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group;

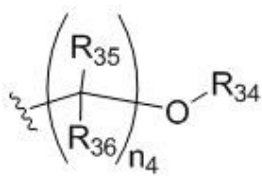
n_1 is an integer from 1 to 30; and

R_1 and R_4 are each independently any one acid-dissociable functional group selected from the group consisting of the following formula (3a) and formula (3b),

[Formula 3a]



[Formula 3b]



wherein in the formula (3a) and formula (3b), n_3 and n_4 are each independently an integer from 0 to 10;

R_{32} , R_{33} , R_{35} and R_{36} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group; and

R_{31} and R_{34} are each independently any one selected from the group consisting of a hydrogen atom, an alkyl group, a heteroalkyl group, a cycloalkyl group, a heterocycloalkyl group, an aryl group, an aralkyl group, a heteroaryl group and a heteroaralkyl group.