DESCRIPTION

Title of Invention:

COMPOSITION FOR FORMING COATING FILM FOR REMOVING FOREIGN MATTERS AND SEMICONDUCTOR SUBSTRATE

Technical Field

[0001]

The present invention relates to a composition for forming a coating film for removing foreign matters that can prevent foreign matters from remaining on a substrate by a simple method, a coating film for removing foreign matters, a semiconductor substrate, and a method for producing a processed semiconductor substrate.

Background Art

[0002]

In the production of a semiconductor device, particularly in what is called the post-process, studies have been made on the process of bonding a semiconductor substrate (e.g. a wafer) to a support substrate, subjecting the resultant substrate to back-grinding (grinding), wiring formation steps, and the like and then peeling off the support substrate to form a desired semiconductor substrate.

[0003]

In such a step, foreign matters may be generated, and

removal thereof is required. Therefore, for example, Patent Literatures 1 and 2 each disclose a composition for forming a substrate treatment film and a method for treating a substrate, which can efficiently remove minute particles from the substrate surface and easily remove the formed substrate treatment film from the substrate surface, in a process for forming a substrate treatment film on the surface of the semiconductor substrate and removing foreign matters from this substrate surface.

Citation List

Patent Literature

[0004]

Patent Literature 1: WO 2017/056746 A

Patent Literature 2: WO 2020/008965 A

Summary of Invention

Technical Problem

[0005]

Meanwhile, when a semiconductor substrate is bonded to a support base material, the semiconductor substrate is bonded using an adhesive layer (e.g. a liquid composition containing a polymer, a back-grinding tape, or a dicing tape) having resistance to the subsequent steps (such as a heating step and a chemical liquid treatment step).

Alternatively, a support base material having a pressure-sensitive adhesive layer is used. Thereafter, a step of peeling off the semiconductor substrate is performed. In this instance, the adhesive layer or the pressure-sensitive adhesive layer of the support base material may remain as foreign matters (residue) on the substrate. Such a phenomenon remarkably occurs particularly when an adhesive layer is formed directly on the surface of a semiconductor substrate having wiring and the like previously formed on a substrate or when a support base material having a pressure-sensitive adhesive layer is directly attached on the surface of the semiconductor substrate. In some cases, it is not possible to completely remove the foreign matter, even when cleaning and the like is performed using a known organic solvent, liquid chemical agent, and the like.

Therefore, it is required to prevent a peeling residue generated from an adhesive layer, a pressure-sensitive adhesive layer, or the like from remaining on a semiconductor substrate by a simple method.

Meanwhile, when a film (coating film for removing foreign matters) is used for this purpose, the film is required to be easily removed from the semiconductor substrate after the step of peeling the semiconductor substrate is performed (easy removability).

[0006]

Thus, an object of the present invention is to provide a composition for forming a coating film for removing foreign matters from which a coating film for removing foreign matters having easy removability is obtained, a coating film for removing foreign matters using the composition, a semiconductor substrate, and a method for producing a processed semiconductor substrate.

Solution to Problem

[0007]

As a result of intensive studies to solve the above problem, the present inventors have found that the above problem can be solved, thereby completing the present invention having the following gist.

[0008]

That is, the present invention includes the following items.

[1] A composition for forming a coating film for removing foreign matters, capable of forming a coating film removable by a removing liquid, the composition including:

a film-forming component; and

a solvent,

wherein the film-forming component includes a coordinating compound.

[2] The composition according to [1], wherein the

coordinating compound is a compound capable of coordinating to copper.

[3] The composition according to [1] or [2], wherein the coordinating compound is at least one of:

(I) a compound having two or more hydroxy groups;

(II) a compound having two or more carboxy groups;

(III) a compound having a heterocyclic ring; and

(IV) an acetylene glycol compound.

[4] The compound according to any one of [1] to [3], wherein the film-forming component includes a compound or a polymer as a component other than the coordinating compound.

[5] The composition according to [4], wherein the compound or polymer has at least one of a hydroxy group, a carboxy group, and a heterocyclic ring.

[6] The composition according to any one of [1] to [5], wherein a content of the coordinating compound is 1 mass% to 10 mass% based on the film-forming component.

[7] The composition according to any one of [4] to [6], wherein a content of the compound or polymer is 90 mass% to 99 mass% based on the film-forming component.

[8] The composition according to any one of [1] to [7], wherein the removing liquid is an alkaline removing liquid.

[9] The composition according to any one of [1] to [8], wherein the coating film is in contact with copper.

[10] A coating film for removing foreign matters formed from the composition according to any one of [1] to [9].

[11] A semiconductor substrate having the coating film for removing foreign matters according to [10].

[12] The semiconductor substrate according to [11], wherein the coating film for removing foreign matters is in contact with copper.

[13] A method for producing a processed semiconductor substrate, including:

a first step of producing a laminate by bonding the semiconductor substrate according to [11] to a support base material with the coating film for removing foreign matters interposed therebetween;

a second step of processing the laminate;

a third step of peeling off the support base material from the laminate; and

a fourth step of cleaning the semiconductor substrate or the support base material with a removing liquid to remove the coating film for removing foreign matters.

[14] The method for producing a processed semiconductor substrate according to [13], wherein the coating film for removing foreign matters is in contact with copper in the laminate.

[15] The method for producing a processed semiconductor substrate according to [13] or [14], wherein in the fourth

step, the foreign matters are removed together with the coating film for removing foreign matters.

[16] The method for producing a processed semiconductor substrate according to any one of [13] to [15], wherein the first step is a step of producing a laminate by bonding the semiconductor substrate to the support base material with the coating film for removing foreign matters and an adhesive layer interposed therebetween.

[17] The method for producing a semiconductor substrate according to [16], wherein in the fourth step, the foreign matters as a peeling residue of the adhesive layer are removed together with the coating film for removing foreign matters.

[18] The method for producing a processed semiconductor substrate according to any one of [13] to [17], wherein the processing includes connecting the semiconductor substrate to a second semiconductor substrate.

Advantageous Effects of Invention

[0009]

In addition, the present invention can provide a composition for forming a coating film for removing foreign matters from which a coating film for removing foreign matters having easy removability is obtained, a coating film for removing foreign matters and a semiconductor

substrate using the composition, and a method for producing a processed semiconductor substrate.

Brief Description of Drawings

[0010]

[Fig. 1A] Fig. 1A is a schematic cross-sectional view for explaining an example of a method for producing a processed semiconductor substrate (part 1).

[Fig. 1B] Fig. 1B is a schematic cross-sectional view for explaining the example of the method for producing a processed semiconductor substrate (part 2).

[Fig. 1C] Fig. 1C is a schematic cross-sectional view for explaining the example of the method for producing a processed semiconductor substrate (part 3).

[Fig. 1D] Fig. 1D is a schematic cross-sectional view for explaining the example of the method for producing a processed semiconductor substrate (part 4).

[Fig. 1E] Fig. 1E is a schematic cross-sectional view for explaining the example of the method for producing a processed semiconductor substrate (part 5).

[Fig. 1F] Fig. 1F is a schematic cross-sectional view for explaining the example of a method for producing a processed semiconductor substrate (part 6).

[Fig. 1G] Fig. 1G is a schematic cross-sectional view for explaining the example of the method for producing a

processed semiconductor substrate (part 7).

[Fig. 2A] Fig. 2A is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 1).

[Fig. 2B] Fig. 2B is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 2).

[Fig. 2C] Fig. 2C is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 3).

[Fig. 2D] Fig. 2D is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 4).

[Fig. 2E] Fig. 2E is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 5).

[Fig. 2F] Fig. 2F is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 6).

[Fig. 2G] Fig. 2G is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 7).

[Fig. 2H] Fig. 2H is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 8).

[Fig. 2I] Fig. 2I is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 9).

[Fig. 2J] Fig. 2J is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 10).

[Fig. 2K] Fig. 2K is a schematic cross-sectional view for explaining the other example of the method for producing a processed semiconductor substrate (part 11).

Description of Embodiments

[0011]

(Composition for forming coating film for removing foreign matters)

A composition for forming a coating film for removing foreign matters of the present invention contains a film-forming component and a solvent.

The film-forming component contains a coordinating compound.

Preferably, the composition for forming a coating film for removing foreign matters can form a coating film that is removable by a removing liquid.

The film-forming component refers to a component other than the solvent in the composition for forming a coating film for removing foreign matters.

[0012]

The present inventors have found that when the coating film formed from the composition for forming a coating film for removing foreign matters is removed by using a removing liquid, the film may remain and the removal by the removing liquid may be difficult.

As a result of investigations, the present inventors have found that the removal by the removing liquid tends to be difficult when the coating film is in contact with a metal (for example, copper).

Therefore, as a result of further investigations, the present inventors have found that a coordinating compound is contained in the composition for forming a coating film for removing foreign matters, thereby allowing prevention of the film from remaining when the coating film is to be removed by the removing liquid, and the easy removability of the coating film can be maintained.

The present inventors consider as follows.

When a metal (for example, copper) in contact with the film diffuses (migrates) into the film and the metal interacts (for example, complexation) with a main component of the film-forming component, the film is difficult to be removed by the removing liquid. Meanwhile, the coordinating compound is contained in the composition for forming a coating film for removing foreign matters,

thereby allowing prevention of the interaction between the main component of the film-forming component and the metal, and as a result, the easy removability of the film can be maintained. The reason why the coordinating compound can prevent the interaction between the main component of the film-forming component and the metal is not clear. As the reason for this, for example, it is considered that the coordinating compound is unevenly distributed at the interface between the film and the metal to prevent the metal from diffusing into the film, and the metal diffused into the film and the coordinating compound preferentially interact with each other.

In addition, the metal in contact with the film migrates to the film surface, and a thin oxide film is formed, leading to a state in which the removal by the removing liquid is difficult. Meanwhile, the coordinating compound is contained in the composition for forming a coating film for removing foreign matters, whereby the coordinating compound can trap metal and inhibit the formation of an oxide film. Therefore, the easy removability can be maintained.

[0013]

In view of the above points, the coating film is preferably in contact with the metal from the viewpoint of more suitably obtaining the effect of the present

invention. Examples of the metal include “metal capable of coordination” described later.

The metal with which the coating film is in contact is, for example, a metal present on the semiconductor substrate. Such a metal is, for example, a metal as an electrode. Examples of the electrode include bumps.

[0014]

<Film-forming component>

The film-forming component contains a coordinating compound.

The film-forming component preferably further contains a compound or a polymer.

In the present invention, the “compound or polymer” is a component different from a coordinating compound, a crosslinking agent to be described later, an additive to be described later, and the like.

The “compound or polymer” is, for example, a main component of the film-forming component. The main component of the film-forming component refers to, for example, occupying 50 mass% or more of the film-forming component.

[0015]

<<Coordinating compound>>

The coordinating compound can coordinate to a metal. The coordinating compound is also referred to as a complex-

forming compound. The coordinating compound forms a complex by being coordinated to a metal or a metal ion.

Examples of the metal capable of coordination include copper, aluminum, chromium, iron, nickel, zinc, molybdenum, cobalt, manganese, tantalum, titanium, tungsten, ruthenium, gold, silver, and platinum, and copper is preferable.

[0016]

The coordinating compound has, for example, a functional group. Examples of the functional group include a hydroxy group, a carboxy group, and a mercapto group.

[0017]

In the present invention, OH in the =N-OH group is regarded as one form of a hydroxy group. OH in the -COOH group (carboxy group) is not considered as a form of hydroxy group.

[0018]

When the coordinating compound has a hydroxy group, the number thereof may be one, two, three, four, five, or six.

[0019]

When the coordinating compound has a hydroxy group, the hydroxy group may be a phenolic hydroxy group or may not be a phenolic hydroxy group.

[0020]

When the coordinating compound has a carboxy group, the number thereof may be one, two, three, four, five, or six.

[0021]

The coordinating compound may have a ring structure. The ring structure may be, for example, a 5-membered ring, a 6-membered ring, a 7-membered ring, or a fused ring of two or more kinds thereof.

When the coordinating compound has a ring structure, the number of ring structures is not particularly limited, and may be one, two, three, or four.

[0022]

The coordinating compound may or may not have an aromatic ring. Examples of the aromatic ring include an aromatic hydrocarbon ring and an aromatic heterocyclic ring. Examples of the aromatic hydrocarbon ring include a benzene ring and a naphthalene ring. Examples of the aromatic heterocyclic ring include a furan ring, a pyrrole ring, a thiophene ring, and a pyridine ring.

[0023]

The atom constituting the coordinating compound is not particularly limited.

The coordinating compound may be a compound composed only of a carbon atom, a hydrogen atom, and an oxygen atom, a compound composed only of a carbon atom, a hydrogen atom, an oxygen atom, and a nitrogen atom, or a compound composed only of a carbon atom, a hydrogen atom, an oxygen atom, a nitrogen atom, and a sulfur atom.

[0024]

The coordinating compound may or may not have a halogen atom.

The coordinating compound may or may not have a carbonyl bond (CO).

[0025]

Examples of the heterocyclic ring in the compound having a heterocyclic ring include a 5-membered ring, a 6-membered ring, and a 7-membered ring.

Examples of the hetero atom of the heterocyclic ring include an oxygen atom, a nitrogen atom, and a sulfur atom.

Examples of the heterocyclic ring include an isocyanuric ring, a pyrazolone ring, a pyridine ring, and a thiazole ring.

[0026]

The molecular weight of the coordinating compound (for example, molecular weights of the following compounds (I) to (III)) is not particularly limited, and is, for example, 100 to 500.

[0027]

Examples of the coordinating compound include the following compounds.

(I) A compound having two or more hydroxy groups

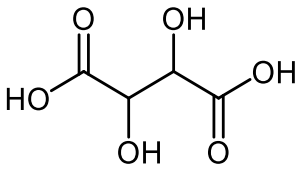
(II) A compound having two or more carboxy groups

(III) A compound having a heterocyclic ring

(IV) An acetylene glycol compound

A certain compound may be applied to both (I) and (II). For example, tartaric acid (the following structure) is a compound of (I) and is also a compound of (II).

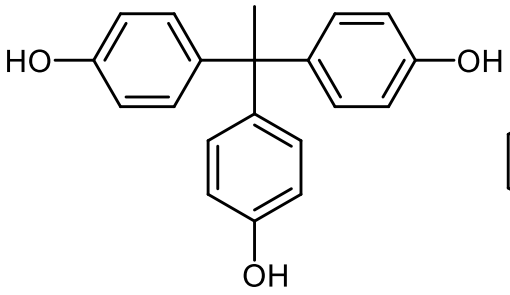
[Chem. 1]

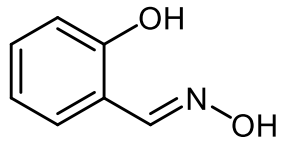


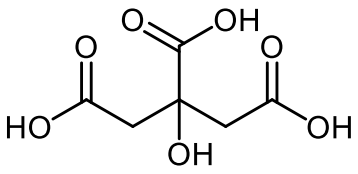
[0028]

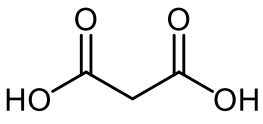
Examples of the compounds (I) to (III) include the following compounds.

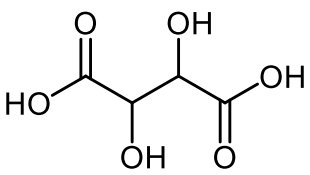
[Chem. 2]

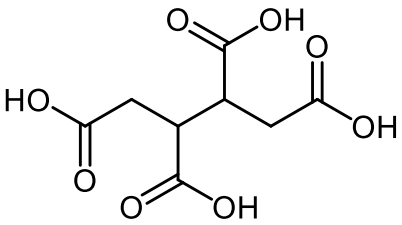


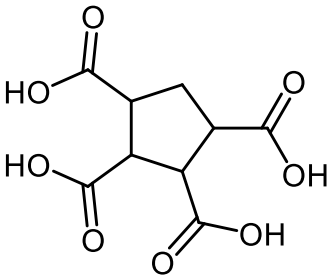


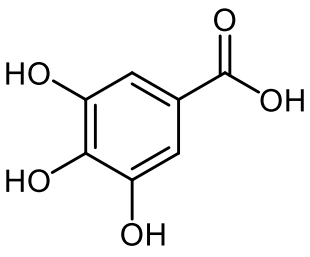


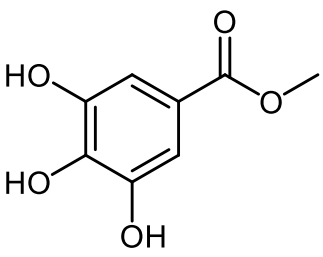




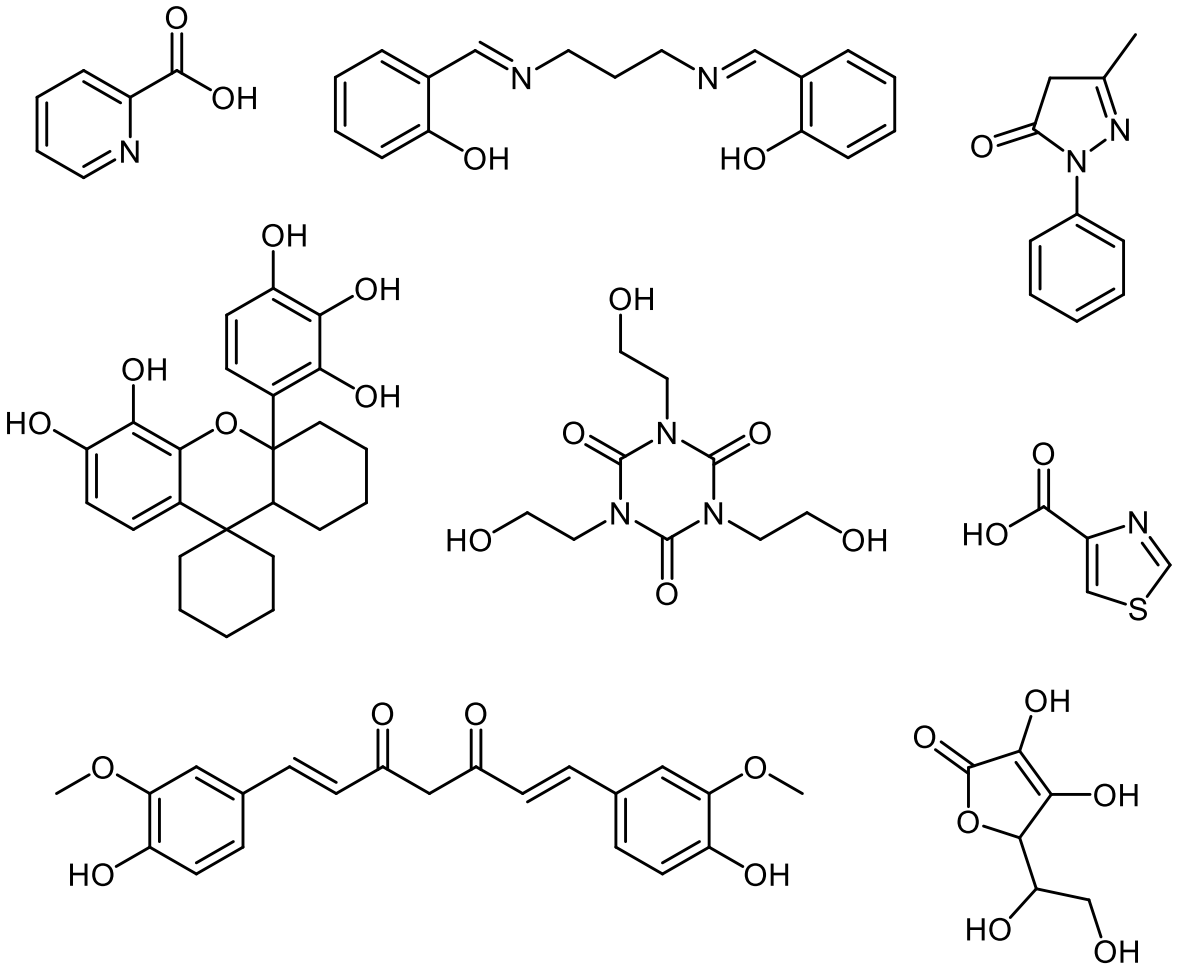








[Chem. 3]



[0029]

(IV) The acetylene glycol compound is an oxyalkylene adduct of an acetylene diol formed by adding an oxyalkylene having 2 or 3 carbon atoms to an acetylene diol.

[0030]

Examples of the acetylene diol include 2,4,7,9-tetramethyl-5-decyne-4,7-diol, 2,5,8,11-tetramethyl-6-dodecyne-5,8-diol, 2-butyne-1,4-diol, 3,6-dimethyl-4-octyne-3,6-diol, and 3-hexyne-2,5-diol.

[0031]

The oxyalkylene having 2 or 3 carbon atoms is ethylene oxide (oxyethylene) or propylene oxide (oxypropylene), preferably ethylene oxide.

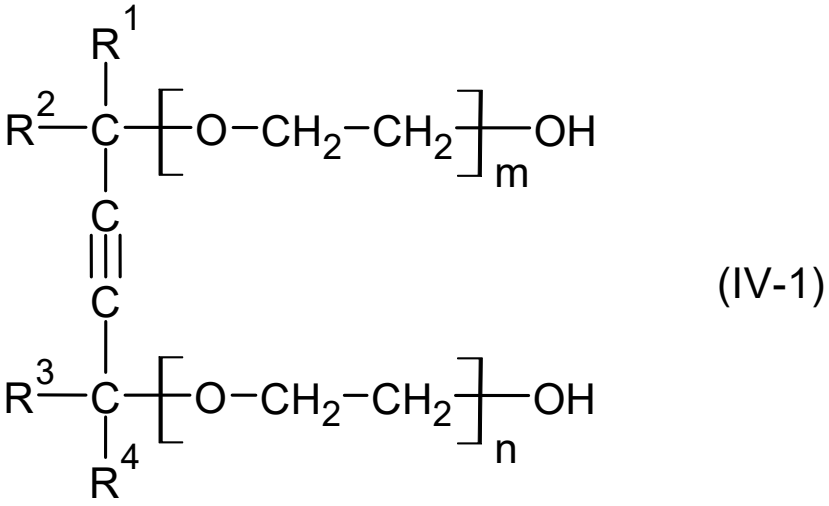
[0032]

The average number of added moles of the oxyalkylene of the oxyalkylene adduct of the acetylene diol is, for example, 1 to 20, preferably 2 to 20, and more preferably 4 to 10.

[0033]

The acetylene glycol compound is represented by, for example, the following formula (IV-1).

[Chem. 4]



(IV-1)

In formula (IV-1), R^1, R^2, R^3, and R^4 each independently represent a hydrogen atom or an alkyl group having 1 to 10 carbon atoms.

m and n are each an integer of 0 or more.

[0034]

The sum of n and m is, for example, 1 to 20, preferably 2 to 20, and more preferably 4 to 10.

As R^1 to R^4, it is preferable that R^2 and R^3 are a methyl group, and R^1 and R^4 are an isobutyl group (-$CH_2CH(CH_3)_2$).

[0035]

The acetylene glycol compound may be a commercially available product. Examples of commercially available products of the acetylene glycol compound include Surfynol (registered trademark) or Olfine (registered trademark) manufactured by Nissin Chemical Industry Co., Ltd., and Acetylenol (registered trademark) manufactured by Kawaken Fine Chemicals Co., Ltd.

[0036]

The content of the coordinating compound is not particularly limited, but is preferably 0.1 mass% to 20 mass%, more preferably 0.5 mass% to 15 mass%, and particularly preferably 1 mass% to 10 mass% based on the film-forming component.

[0037]

The content of the coordinating compound in the composition for forming a coating film for removing foreign matters is not particularly limited, but is preferably 0.1 mass% to 20 mass%, more preferably 0.5 mass% to 15 mass%, and particularly preferably 1 mass% to 10 mass% based on

“compound or polymer”.

[0038]

<<Compound or polymer>>

The compound or polymer that is a main component of the film-forming component is not particularly limited, but the compound or polymer has, for example, a polar group. Examples of the polar group include a hydroxy group and a carboxy group.

[0039]

The compound or polymer has, for example, a heterocyclic ring. Examples of the heterocyclic ring include a lactam ring.

[0040]

Hereinafter, polymers (A) to (I) and a compound (A) are introduced as examples of a compound or a polymer.

[0041]

<<<Polymer (A)>>>

The polymer (A) is a polymer having at least one of a phenolic hydroxy group and a carboxy group.

[0042]

The sum of the numbers of phenolic hydroxy groups and carboxy groups contained in the polymer (A) is, for example, two or more. In this case, the number of phenolic hydroxy groups may be two or more and no carboxy group may be contained, or the number of carboxy groups may be two or

more and no phenolic hydroxy group may be contained.

[0043]

The polymer (A) is not particularly limited as long as it has a phenolic hydroxy group and/or a carboxy group, and examples thereof include phenol novolac, cresol novolac, polyhydroxystyrene, polyamic acid, and polyacrylic acid.

[0044]

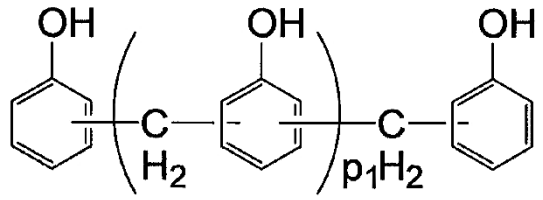
It is possible to use, as the polymer (A), those in which all of the units (repeating unit structures) constituting the polymer have phenolic hydroxy groups or carboxyl groups. It is also possible to use a polymer composed of a unit having a phenolic hydroxy group or a carboxyl group and a unit having neither a phenolic hydroxy group nor a carboxyl group. When such a polymer composed of a unit having a phenolic hydroxy group or a carboxyl group and a unit not having a phenolic hydroxy group or a carboxyl group is used, the molar ratio of the unit having a phenolic hydroxy group or a carboxyl group in the polymer is preferably 1% or more, for example, 10% or more, particularly 20% or more, but is 5% to 100%, for example, 10% to 100%, preferably 20% to 100%, more preferably 30% to 100%, based on the total units constituting the polymer.

[0045]

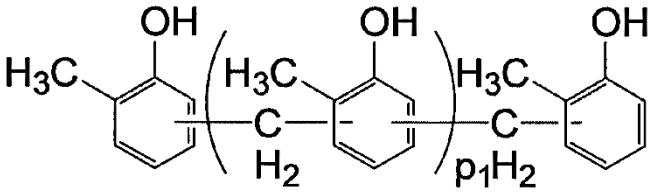
Examples of the polymer (A) include polymers represented by the following formulas (4) to (23) and (26)

to (35). In the formulas, p_1, p_2, p_3, and p_4 each represent a molar ratio of each unit in the polymer, and a sum thereof represents a value of 100%.

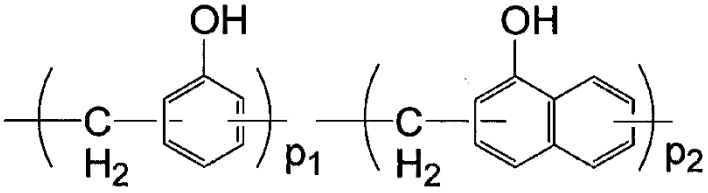
[Chem. 5]



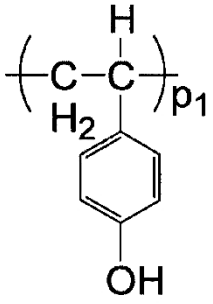
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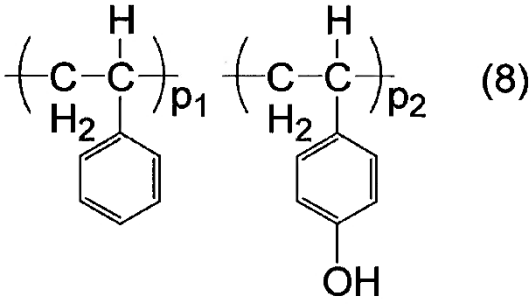
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(6)

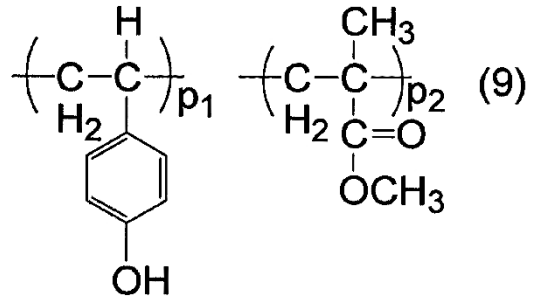


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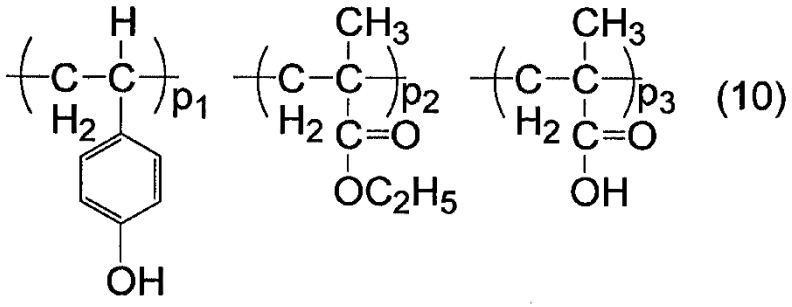


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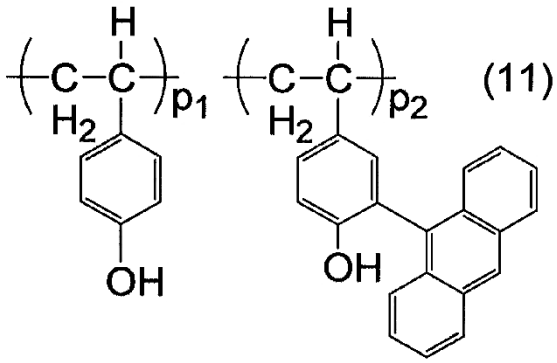
[Chem. 6]



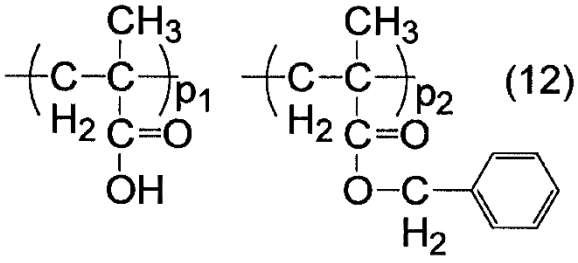
(9)



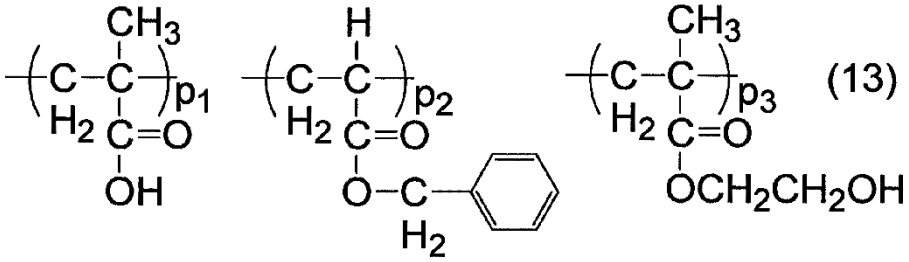
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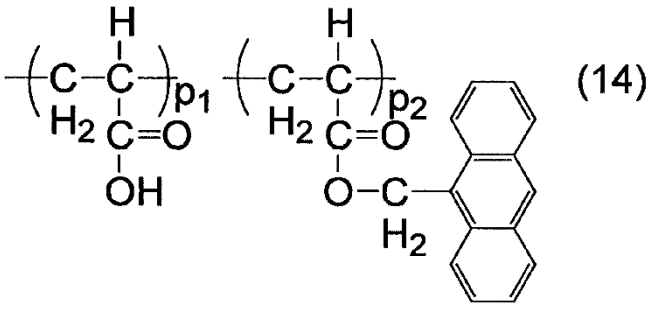


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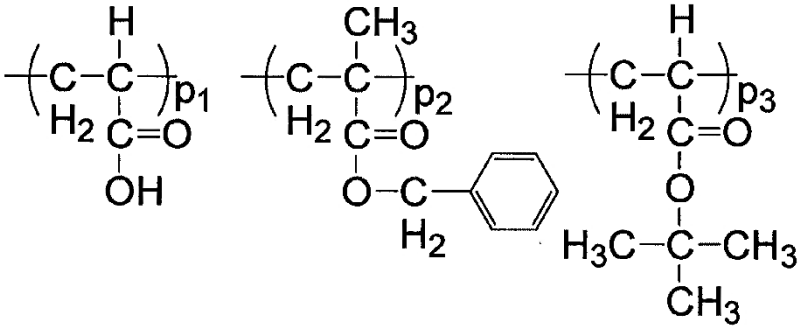


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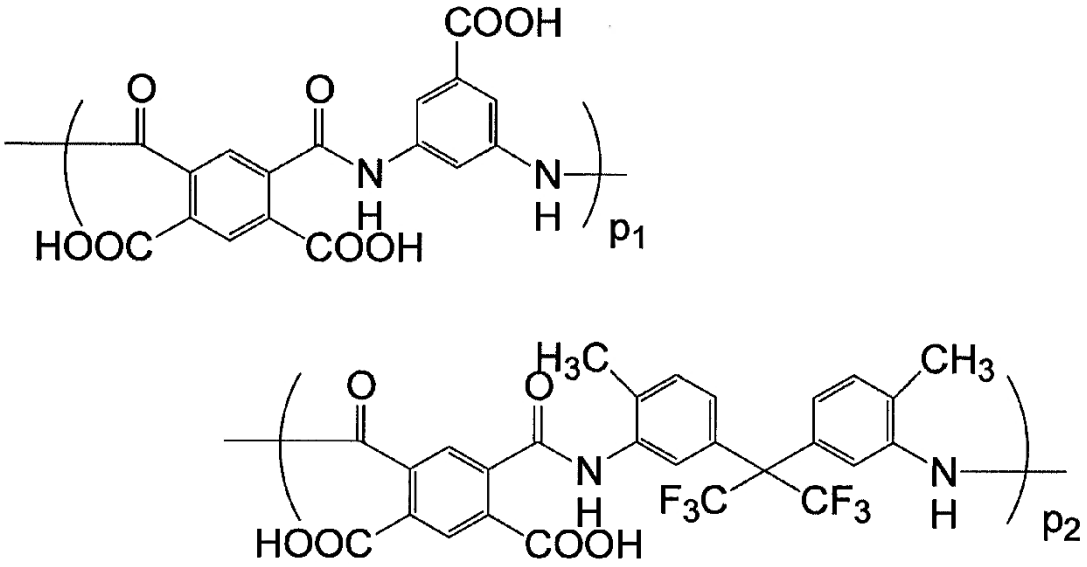


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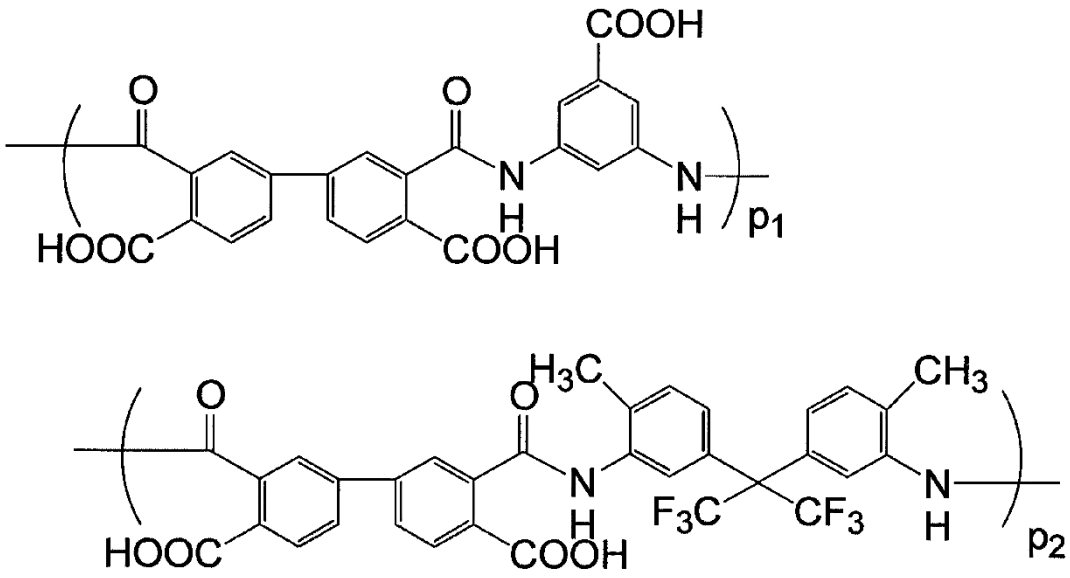


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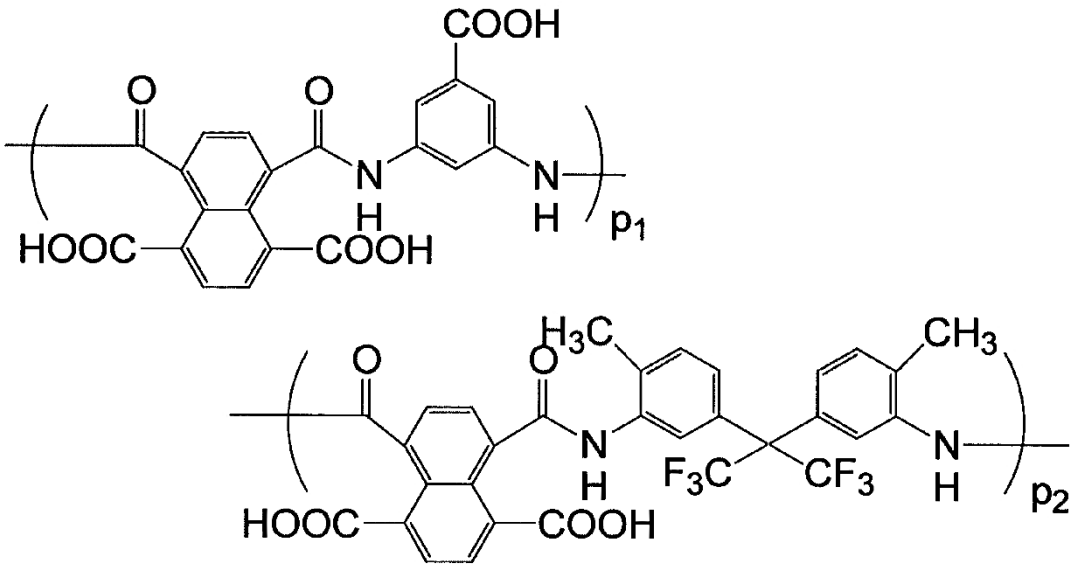

COOH
O
O
N
H
N
H
HOOC
COOH
p1
H3C
CH3
F3C
CF3
p2

(16)

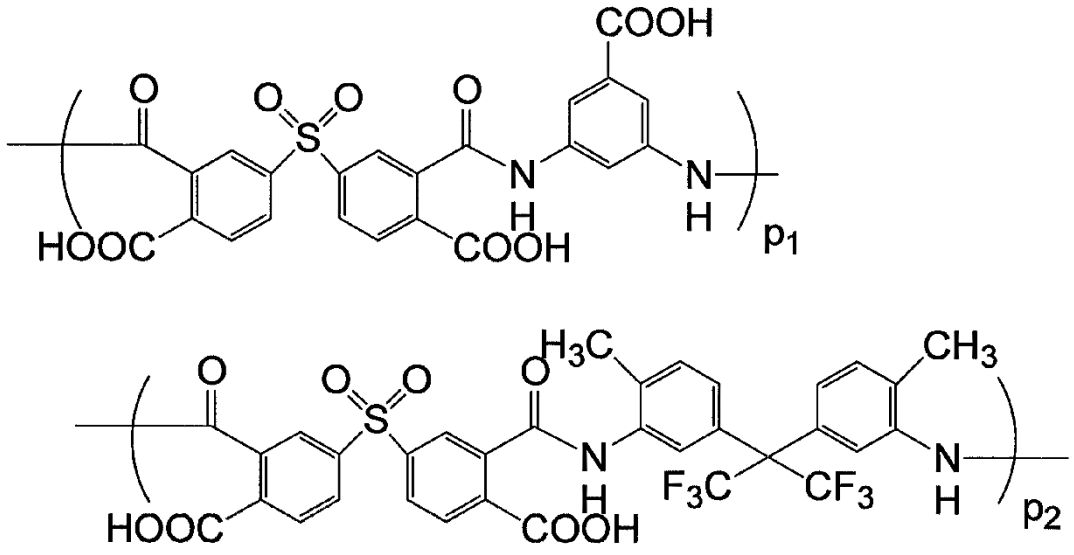

COOH
O
O
N
H
N
H
HOOC
COOH
p1
H3C
CH3
F3C
CF3
p2

(17)

[Chem. 9]

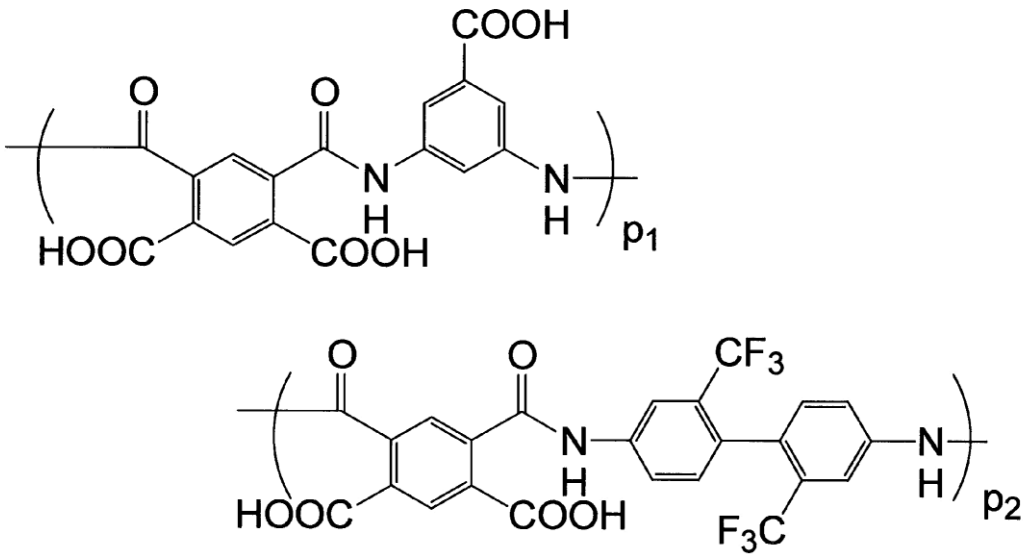

COOH
O
O
N
H
N
H
p1
HOOC
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H3C
CH3
O
O
N
H
F3C
CF3
N
H
p2
HOOC
COOH

(18)

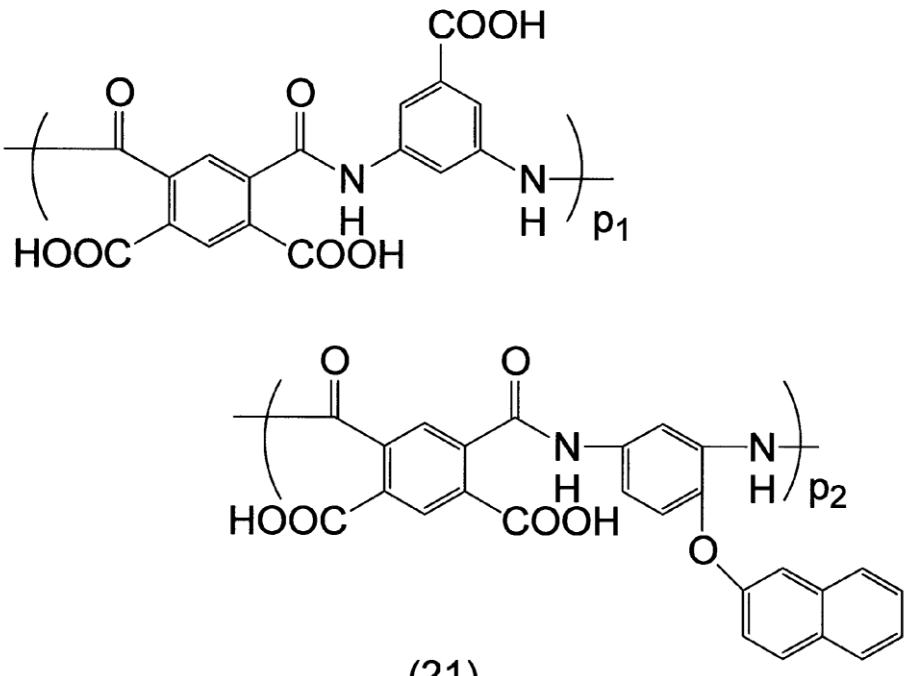

COOH
O
O
S
O
O
N
H
N
H
p1
HOOC
COOH
H3C
CH3
O
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O
O
N
H
F3C
CF3
N
H
p2
HOOC
COOH

(19)

[Chem. 10]

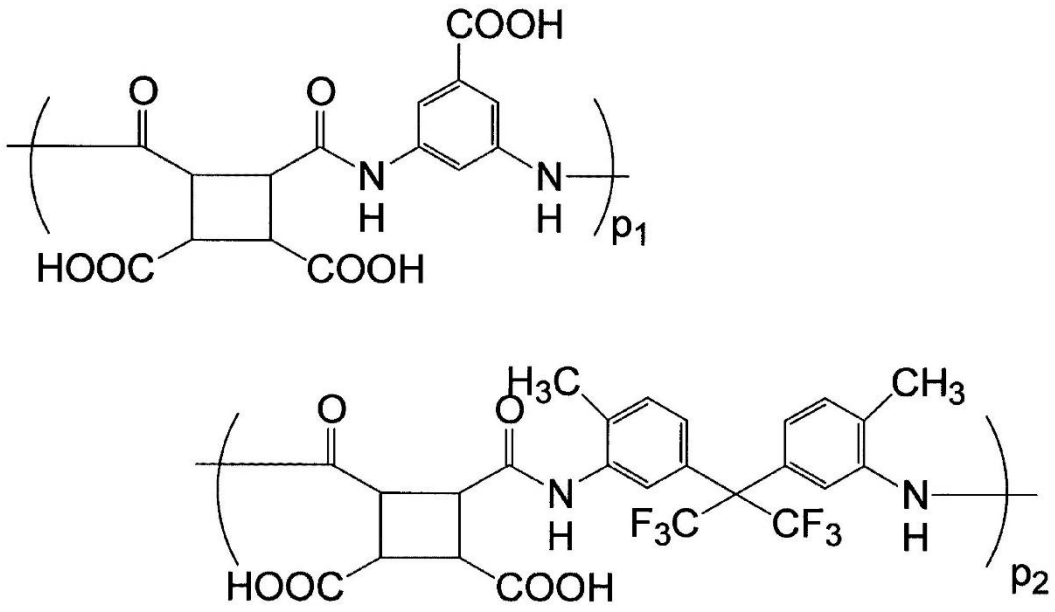

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O
O
N
H
N
H
HOOC
COOH
p1
CF3
F3C
p2

(20)

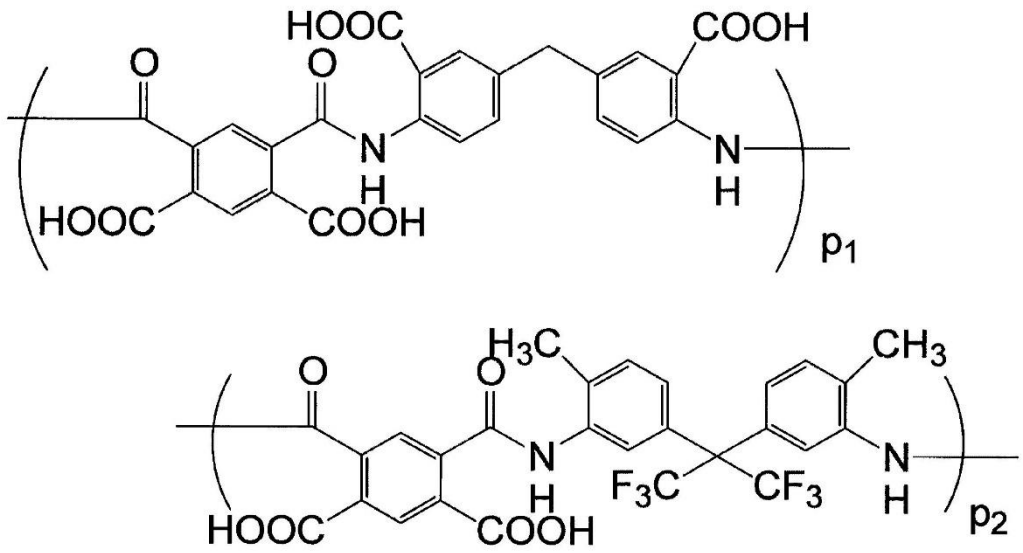

COOH
O
O
N
H
N
H
HOOC
COOH
p1
p2

(21)

[Chem. 11]

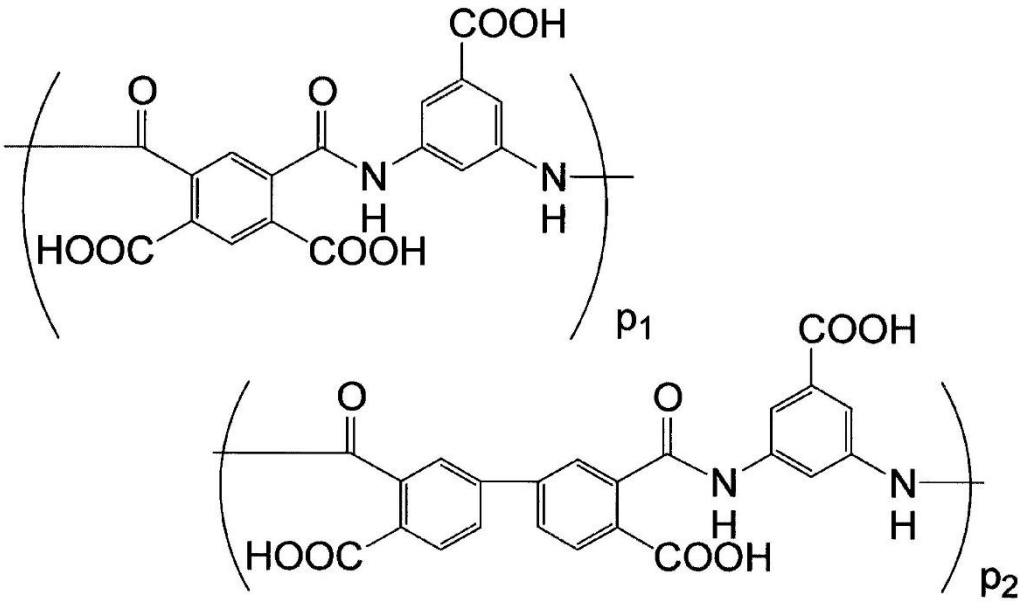


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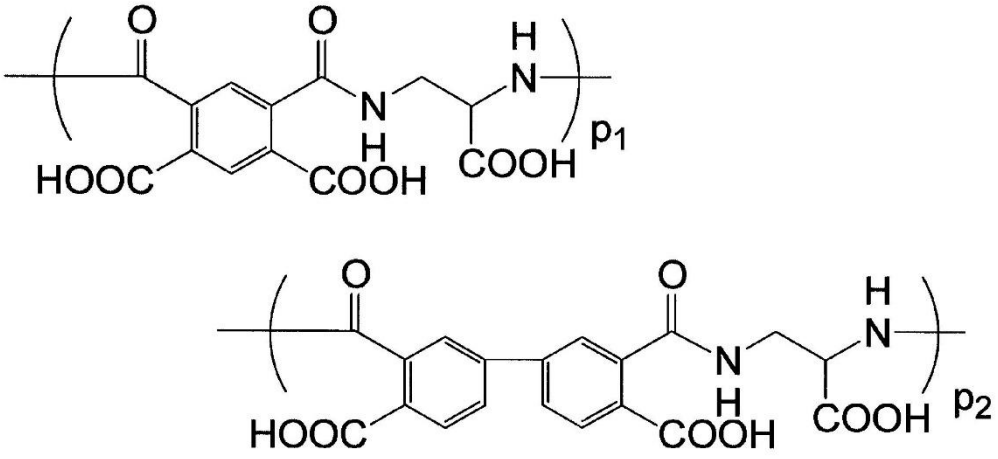


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[Chem. 12]

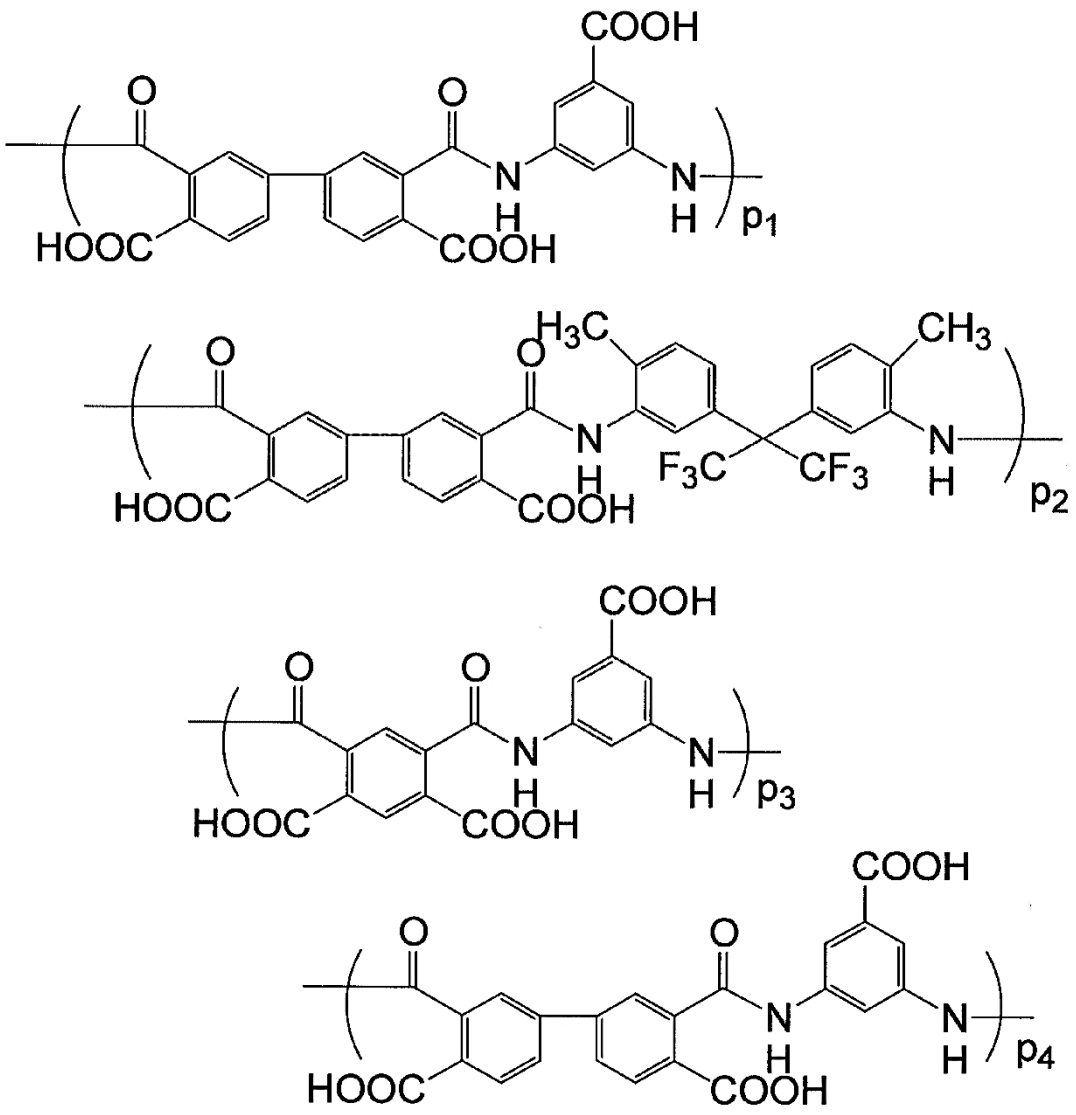

COOH
O
O
N
H
N
H
HOOC
COOH
p1
COOH
O
O
N
H
N
H
HOOC
COOH
p2

(26)


O
O
N
H
H
N
HOOC
COOH
COOH
p1
O
O
N
H
H
N
HOOC
COOH
COOH
p2

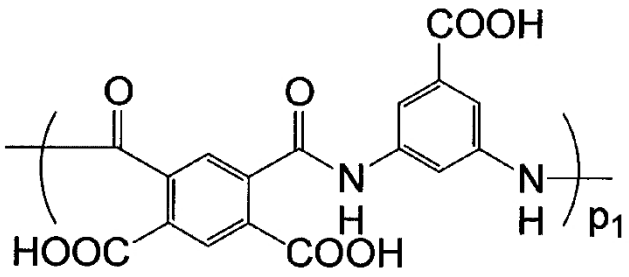
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[Chem. 13]

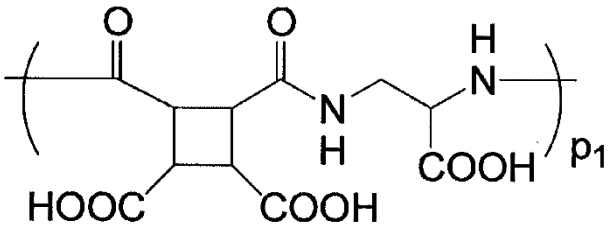


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[Chem. 14]

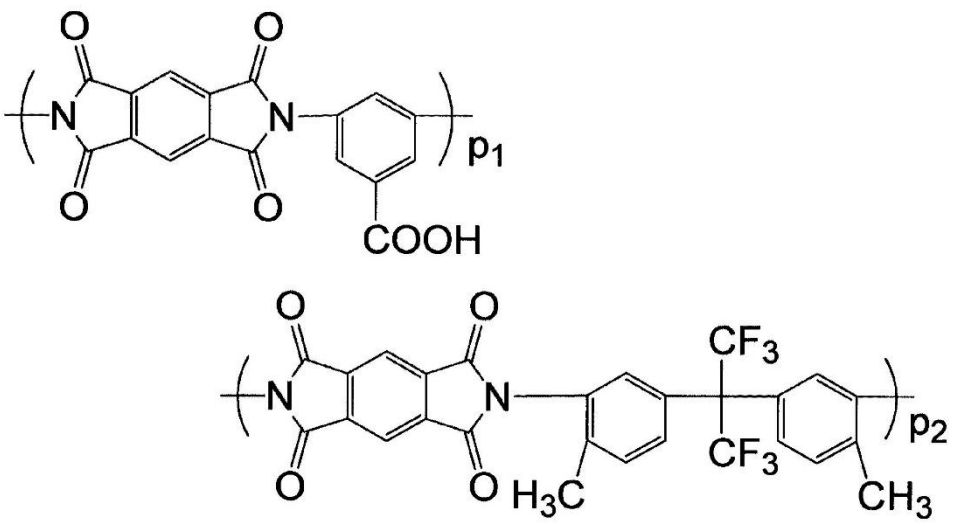


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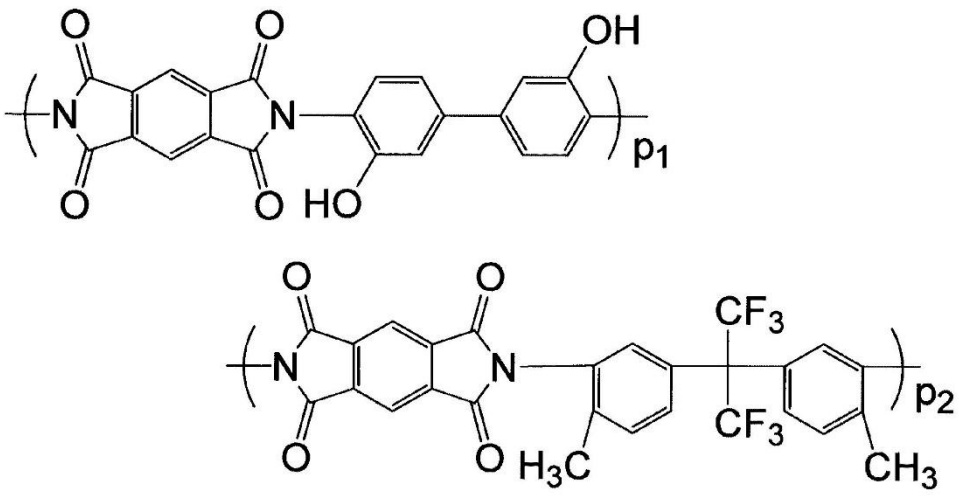


(30)

[Chem. 15]

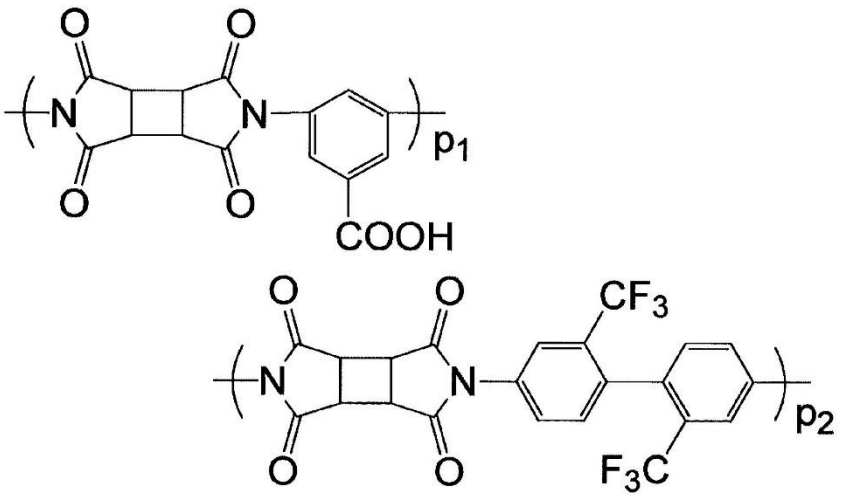


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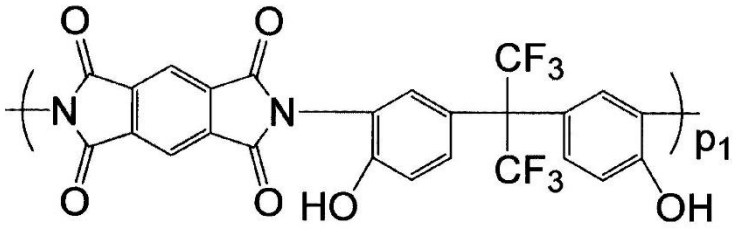


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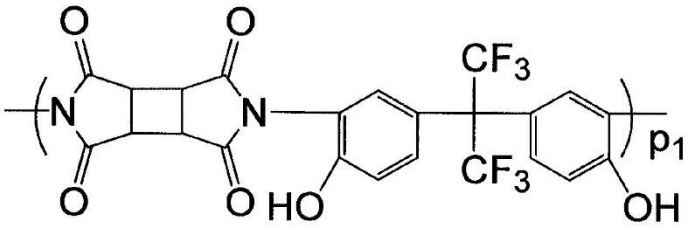
[Chem. 16]



(33)



(34)



(35)

[0046]

Examples of the polymer (A) include a polymer (e.g., polyhydroxystyrene) containing a hydroxystyrene unit (repeating unit derived from hydroxystyrene). Examples of the polymer (A) also include a polymer produced by

copolymerization of a compound having an addition polymerizable double bond (e.g., an acrylic acid ester compound, a methacrylic acid ester compound, maleimide, a vinyl ether compound) and hydroxystyrene. Polymers of formulas (8) to (11) are examples. The hydroxystyrene unit is preferably contained in a molar ratio of 10% or more based on all the units constituting the polymer. The molar ratio of the hydroxystyrene unit in the polymer is 10% or more, preferably 20% or more, for example, 10% to 100%, preferably 20% to 100%, and more preferably 30% to 100% based on all the units constituting the polymer.

[0047]

Examples of the polymer (A) also include a polymer containing an acrylic acid unit or a methacrylic acid unit (e.g., a polyacrylic acid or polymethacrylic acid polymer). Further examples of the polymer (A) also include a polymer produced from a compound having an addition polymerizable double bond (e.g., an acrylic acid ester compound, a methacrylic acid ester compound, a styrene compound) and acrylic acid or methacrylic acid. Polymers of formulas (10) and (12) to (15) are examples. The acrylic acid unit or the methacrylic acid unit is preferably contained in a molar ratio of 10% or more based on all the units constituting the polymer. The molar ratio of the acrylic acid unit or methacrylic acid unit in the polymer is 10% or

more, preferably 20% or more, for example, 10% to 100%, preferably 20% to 90%, and more preferably 30% to 70% based on all the units constituting the polymer.

[0048]

Examples of the polymer (A) also include polyimide. The polyimide used in the present invention may be produced from a tetracarboxylic dianhydride compound and a diamine compound having a phenolic hydroxy group or a carboxyl group. Examples of such a polyimide include polyimides of formulas (31) to (35). For example, the polyimide of formula (31) may be obtained by reacting a 1,2,4,5-benzenetetracarboxylic dianhydride compound with 3,5-diaminobenzoic acid and 2,2-bis(3-amino-4-tolyl)hexafluoropropane.

[0049]

Examples of the polymer (A) also include polyamic acid. The polyamic acid may be produced by reacting a diamine compound with a tetracarboxylic acid or its derivative, namely tetracarboxylic dianhydride compound and/or a dicarboxylic dihalide or the like. The polyamic acid may also be produced by synthesizing a polyamide acid silyl ester by polymerization using a bis-silylated diamine compound and a tetracarboxylic dianhydride compound, and then decomposing a silyl ester moiety by using an acid. Examples of the polyamic acid used in the present invention

include polyamic acids of formulas (16) to (23) and (26) to (30). For example, the polyamic acid of formula (20) may be obtained by reacting a 1,2,4,5-benzenetetracarboxylic dianhydride compound with 3,5-diaminobenzoic acid and 2,2'-bis(trifluoromethyl)-4,4'-diaminobiphenyl.

[0050]

Examples of the polymer (A) include a polymer produced from a compound having at least two epoxy groups and a compound having at least two phenolic hydroxy groups or carboxyl groups. Examples of such a polymer include a polymer produced from a compound having at least two, for example, two to six epoxy groups and a compound having at least two, for example, two to six phenolic hydroxy groups or carboxyl groups.

Such a polymer can be produced by reacting a compound having at least two epoxy groups with a compound having at least two phenolic hydroxy groups or carboxyl groups in an approximately equimolar amount with respect to the epoxy groups, in the presence of a catalyst such as a quaternary ammonium salt.

Examples of the compound having at least two epoxy groups include tris(2,3-epoxypropyl)isocyanurate, 1,4-butanediol diglycidyl ether, 1,2-epoxy-4-(epoxyethyl)cyclohexane, glycerol triglycidyl ether, diethylene glycol diglycidyl ether, 2,6-diglycidyl phenyl

glycidyl ether, 1,1,3-tris[p-(2,3-epoxypropoxy)phenyl]propane, 1,2-cyclohexanedicarboxylic acid diglycidyl ester, 4,4’-methylenebis(N,N-diglycidylaniline), 3,4-epoxycyclohexylmethyl-3,4-epoxycyclohexanecarboxylate, trimethylolethane triglycidyl ether, bisphenol-A-diglycidyl ether, and pentaerythritol polyglycidyl ether.

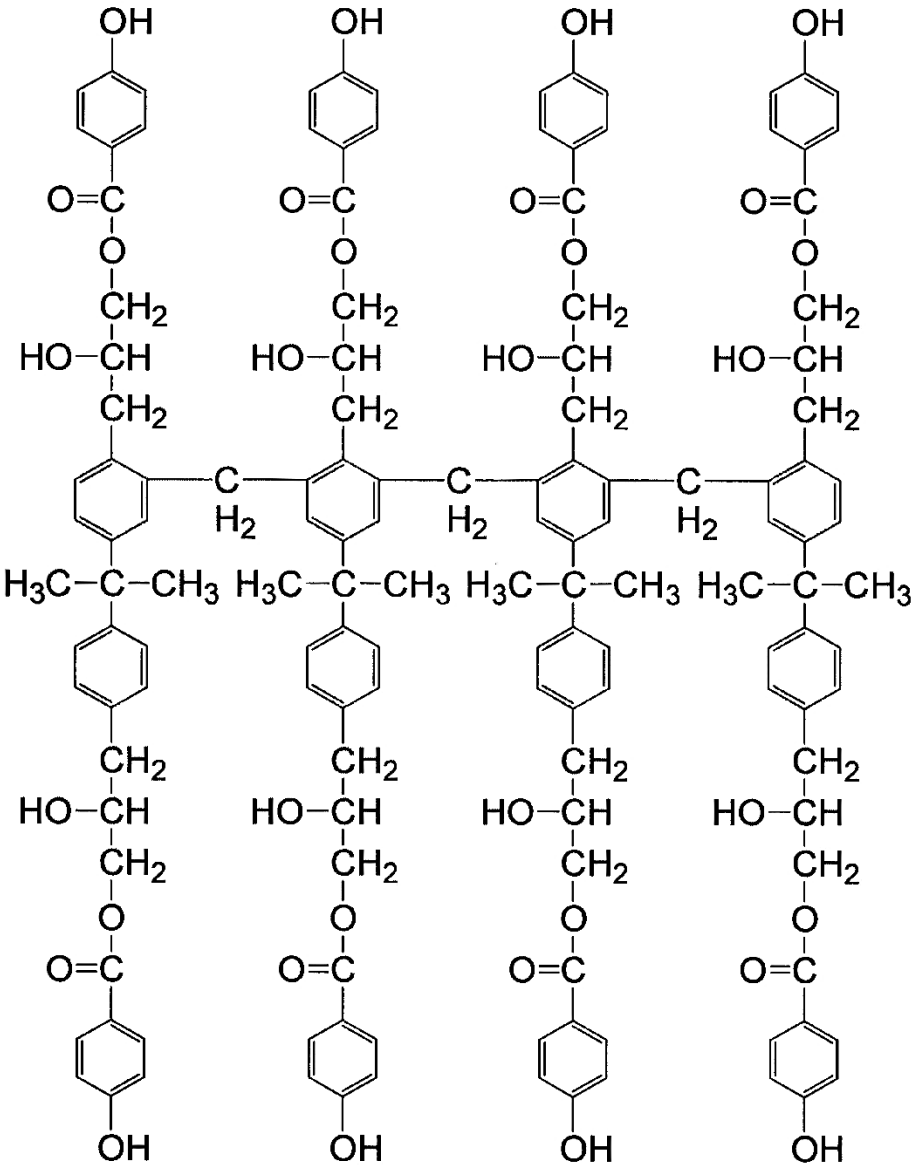
Examples of the compound having at least two phenolic hydroxy groups or carboxyl groups include 1,2,3-anthracenetriol, 2,7,9-anthracenetriol, 2-hydroxy-1-naphthoic acid, 7-hydroxy-1-naphthoic acid, 3-hydroxy-2-naphthoic acid, 2,6-naphthoic acid, 1-hydroxy-4-phenyl-3-naphthoic acid, 6-ethoxy-2,3-naphthalenediol, 4-hydroxybenzoic acid, 2-chloro-4-hydroxybenzoic acid, 2,4-dihydroxy-5-methylbenzoic acid, 3-hydroxybenzoic acid, 5-hydroxyisophthalic acid, 2,5-dihydroxybenzoic acid, terephthalic acid, 2-nitroterephthalic acid, 3,5-dibromo-4-hydroxybenzoic acid, 3,5-dibromo-2,4-dihydroxybenzoic acid, 3-iodo-5-nitro-4-hydroxybenzoic acid, 3,5-diiodo-2-hydroxybenzoic acid, 2,4,6-triiodo-3-hydroxybenzoic acid, 2,4,6-tribromo-3-hydroxybenzoic acid, and 2-bromo-4,6-dimethyl-3-hydroxybenzoic acid.

Examples of the polymer produced from the compound having at least two epoxy groups and the compound having at least two phenolic hydroxy groups or carboxyl groups

include a polymer of formula (43).

[0051]

[Chem. 17]

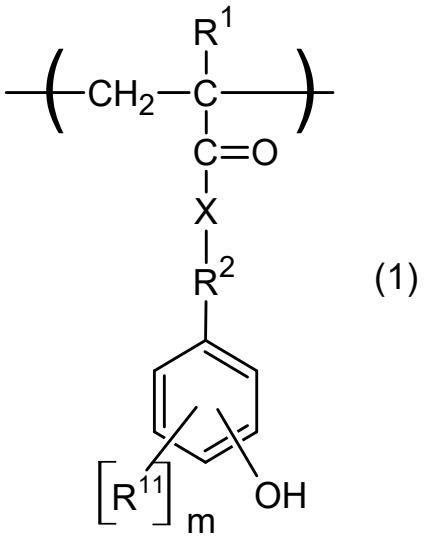


(43)

[0052]

As the polymer (A), a polymer having a unit represented by the following formula (1) can be used.

[Chem. 18]



(1)

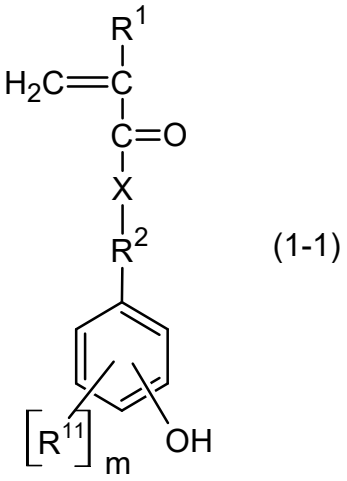
In formula (1), R^1 represents a hydrogen atom or a methyl group. X represents -O- or -N(R^3)- where R^3 represents a hydrogen atom or a methyl group. R^2 represents a single bond or an alkylene group having 1 to 6 carbon atoms. R^{11} represents an alkyl group having 1 to 6 carbon atoms. m represents an integer of 0 to 4. When m is 2 or more, two or more R^{11} are the same or different.

The unit of formula (1) is contained, for example, in a molar ratio of 10% or more based on all the units constituting the polymer. The molar ratio of the unit of formula (1) in the polymer is 10% or more, preferably 20% or more, for example, 10% to 100%, preferably 15% to 80%, more preferably 20% to 70%, and most preferably 25% to 50%.

[0053]

Examples of the monomer that provides the unit represented by formula (1) include a monomer represented by the following formula (1-1).

[Chem. 19]



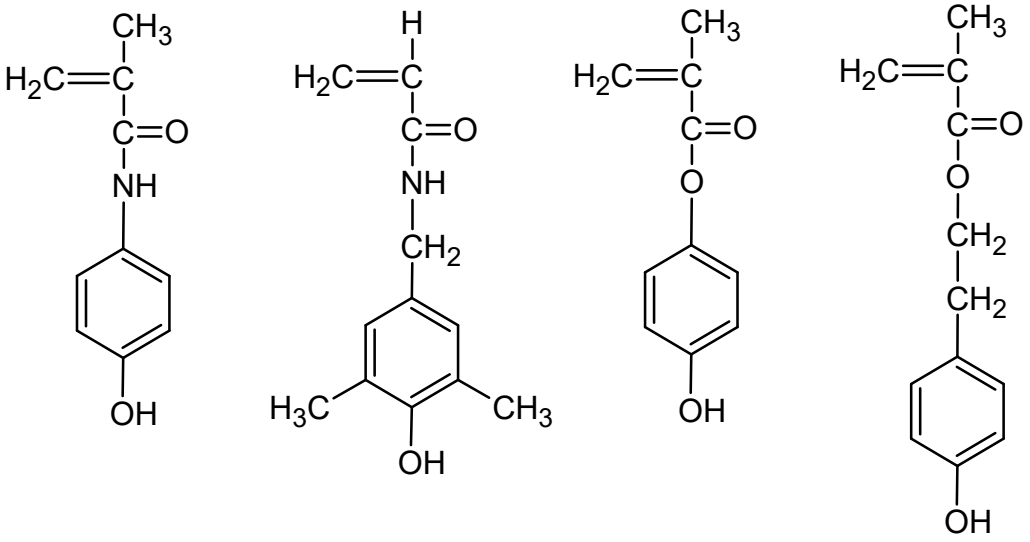
(1-1)

In formula (1-1), R^1 represents a hydrogen atom or a methyl group. X represents -O- or -N(R^3)- where R^3 represents a hydrogen atom or a methyl group. R^2 represents a single bond or an alkylene group having 1 to 6 carbon atoms. R^{11} represents an alkyl group having 1 to 6 carbon atoms. m represents an integer of 0 to 4. When m is 2 or more, two or more R^{11} are the same or different.

[0054]

Examples of the monomer represented by formula (1-1) include the following monomers.

[Chem. 20]



[0055]

The polymer having the unit represented by formula (1) may be produced by polymerizing the monomer represented by formula (1-1) while using a polymerization initiator such as N,N'-azobisisobutyronitrile.

[0056]

The polymer having the unit represented by formula (1) can include other units as long as the proportion of formula (1) in the polymer satisfies the above value. The other unit(s) may be introduced into the polymer by using a polymerizable compound such as acrylic acid, methacrylic acid, an acrylic acid ester compound, a methacrylic acid ester compound, a maleimide compound, acrylonitrile, maleic anhydride, a styrene compound, and a vinyl compound during production of the polymer.

[0057]

Examples of the acrylic acid ester compound include

methyl acrylate, ethyl acrylate, isopropyl acrylate, benzyl acrylate, naphthyl acrylate, anthryl acrylate, anthryl methyl acrylate, phenyl acrylate, 2-hydroxyethyl acrylate, 2-hydroxypropyl acrylate, 2,2,2-trifluoroethyl acrylate, tert-butyl acrylate, cyclohexyl acrylate, isobornyl acrylate, 2-methoxyethyl acrylate, methoxytriethylene glycol acrylate, mono-(2-(acryloyloxy)ethyl)phthalate, 2-ethoxyethyl acrylate, tetrahydrofurfuryl acrylate, 3-methoxybutyl acrylate, 2-methyl-2-adamantyl acrylate, 2-propyl-2-adamantyl acrylate, 8-methyl-8-tricyclodecyl acrylate, 8-ethyl-8-tricyclodecyl acrylate, 5-acryloyloxy-6-hydroxynorbornene-2-carboxylic-6-lactone, and other acrylic acid ester compounds.

[0058]

Examples of the methacrylic acid ester compound include methyl methacrylate, ethyl methacrylate, isopropyl methacrylate, benzyl methacrylate, naphthyl methacrylate, anthryl methacrylate, anthryl methyl methacrylate, phenyl methacrylate, 2-hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate, 2,2,2-trifluoroethyl methacrylate, tert-butyl methacrylate, cyclohexyl methacrylate, isobornyl methacrylate, 2-methoxyethyl methacrylate, methoxytriethylene glycol methacrylate, mono-(2-(methacryloyloxy)ethyl)phthalate, 2-ethoxyethyl methacrylate, tetrahydrofurfuryl methacrylate, 3-

methoxybutyl methacrylate, 2-methyl-2-adamantyl methacrylate, 2-propyl-2-adamantyl methacrylate, 8-methyl-8-tricyclodecyl methacrylate, 8-ethyl-8-tricyclodecyl methacrylate, and 5-methacryloyloxy-6-hydroxynorbornene-2-carboxylic-6-lactone.

[0059]

Examples of the vinyl compounds include vinyl ether, methyl vinyl ether, benzyl vinyl ether, 2-hydroxyethyl vinyl ether, phenyl vinyl ether, propyl vinyl ether, and other vinyl compounds.

[0060]

Examples of the styrene compounds include styrene, methylstyrene, chlorostyrene, bromostyrene, hydroxystyrene, and other styrene compounds.

[0061]

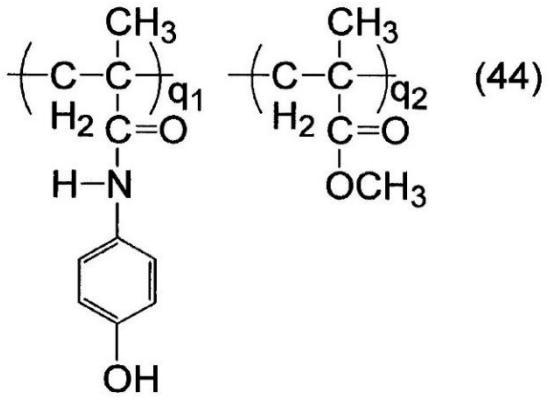
Examples of the maleimide compounds include maleimide, N-methylmaleimide, N-phenylmaleimide, N-cyclohexylmaleimide, and other maleimide compounds.

[0062]

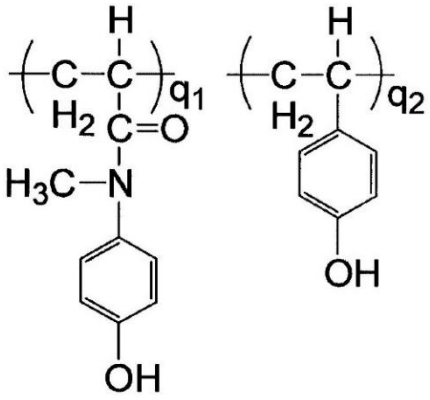
Examples of the polymer having a unit represented by formula (1) include polymers of formulas (44) to (49). In the formulas, q_1, q_2, q_3, and q_4 each represent a molar ratio of each unit in the polymer, q1 is 10% or more, and a sum thereof represents a value of 100%.

[0063]

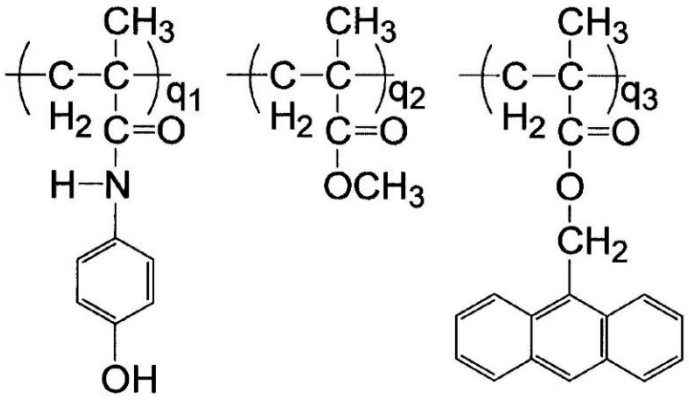
[Chem. 21]



(44)

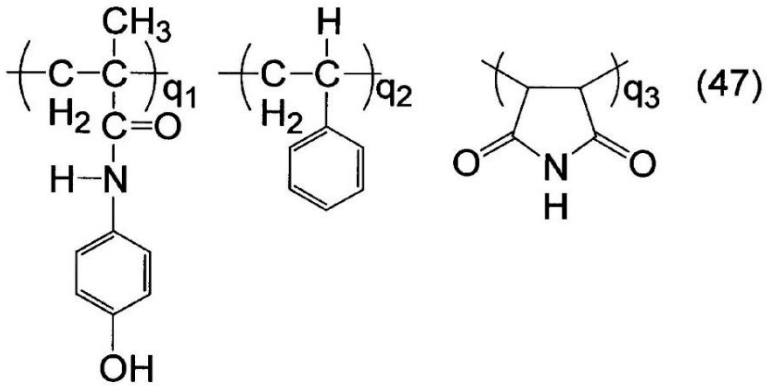


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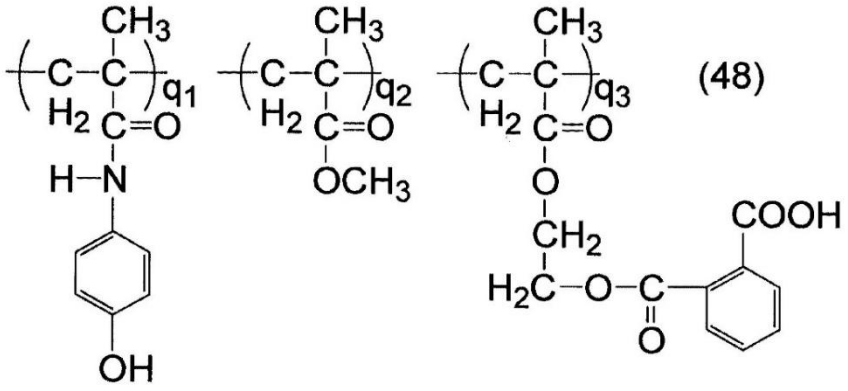


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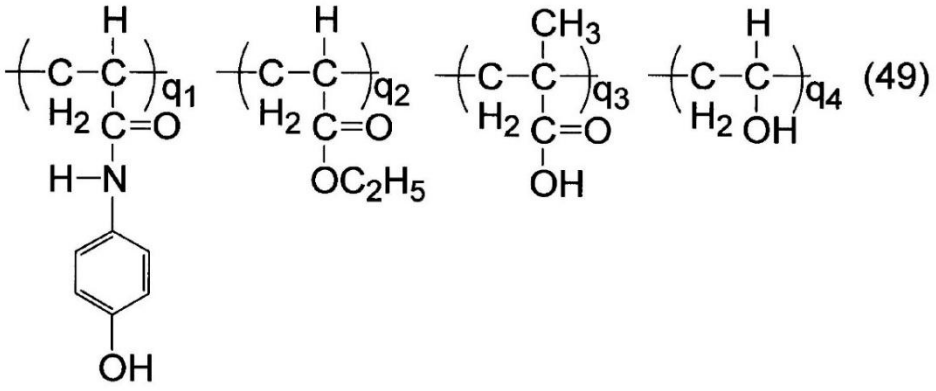
[Chem. 22]



(47)



(48)



(49)

[0064]

In addition, the polymer (A) may be a polyamic acid having a structural unit derived from (a) a tetracarboxylic acid dianhydride compound and (b) a diamine compound having at least one carboxyl group as described in WO 2018/159665 A.

In addition, the polymer (A) may be a phenolic hydroxy group-containing polymer or a carboxy group-containing polymer as described in WO 2022/019287 A.

The contents of these publications are incorporated herein by reference to the same extent as if fully set forth.

[0065]

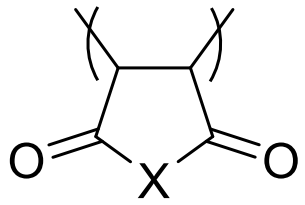
The polymer (A) may be a commercially available product. Examples of the commercially available product include polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.).

[0066]

<<<Polymer (B)>>>

The polymer (B) is a polymer containing a structural unit represented by the following formula (1).

[Chem. 23]



(1)

In formula (1), X represents an oxygen atom or NR, and R represents a hydrogen atom or a protecting group of an imide group that is deprotected by alkali.

[0067]

Examples of the protecting group of an imide group that

is deprotected by alkali in R include a methyl group, a cyclohexyl group, a hydroxyethyl group, a benzyl group, and a phenyl group.

Examples of the alkali include alkalis contained in alkaline removing liquids.

[0068]

The polymer (B) may have a structural unit other than the structural unit represented by formula (1). Such a structural unit is not particularly limited. Examples of the structural unit include a structural unit derived from a compound having a polymerizable unsaturated bond.

[0069]

The ratio of the structural unit represented by formula (1) in the polymer (B) is not particularly limited, and is preferably 50 mol% or more, more preferably 70 mol% or more, still more preferably 80 mol% or more, and particularly preferably 90 mol% or more based on all the structural units.

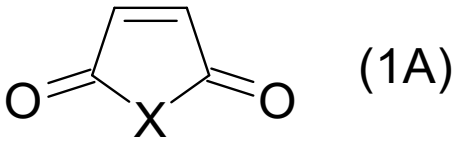
[0070]

The weight average molecular weight of the polymer (B) is not particularly limited, and is preferably 1,000 to 50,000, and more preferably 1,500 to 30,000. The weight average molecular weight is a value obtained by gel permeation chromatography (GPC) using polystyrene as a standard sample.

[0071]

The polymer (B) is prepared, for example, by polymerizing a monomer containing a compound represented by the following formula (1A).

[Chem. 24]



(1A)

In formula (1A), X is synonymous with X in formula (1).

[0072]

Examples of the compound represented by formula (1A) include maleimide, N-methylmaleimide, N-cyclohexylmaleimide, N-hydroxyethylmaleimide, N-benzylmaleimide, N-phenylmaleimide, and maleic anhydride.

[0073]

The polymerization method is not particularly limited, and examples thereof include radical polymerization.

For example, the polymer is prepared by homopolymerization of the compound represented by formula (1A) such as maleimide or copolymerization with another monomer.

[0074]

The monomer used for the polymerization may contain a monomer other than the compound represented by formula (1A). Examples of the monomer include a compound having a

polymerizable unsaturated bond. Specific examples of the compound include, but are not limited to, acrylic acid, methacrylic acid, an acrylate ester compound, a methacrylate ester compound, an acrylamide compound, a methacrylamide compound, a vinyl compound, a styrene compound, and acrylonitrile.

[0075]

Specific examples of the acrylate ester compound include, but are not limited to, methyl acrylate, ethyl acrylate, normal hexyl acrylate, i-propyl acrylate, cyclohexyl acrylate, benzyl acrylate, phenyl acrylate, anthrylmethyl acrylate, 2-hydroxyethyl acrylate, 3-chloro-2-hydroxypropyl acrylate, 2-hydroxypropyl acrylate, 2,2,2-trifluoroethyl acrylate, 2,2,2-trichloroethyl acrylate, 2-bromoethyl acrylate, 4-hydroxybutyl acrylate, 2-methoxyethyl acrylate, tetrahydrofurfuryl acrylate, 2-methyl-2-adamantyl acrylate, 5-acryloyloxy-6-hydroxynorbornene-2-carboxylic-6-lactone, 3-acryloxypropyltriethoxysilane, and glycidyl acrylate.

[0076]

Specific examples of the methacrylate ester compound include, but are not limited to, methyl methacrylate, ethyl methacrylate, normal hexyl methacrylate, i-propyl methacrylate, cyclohexyl methacrylate, benzyl methacrylate, phenyl methacrylate, anthrylmethyl methacrylate, 2-

hydroxyethyl methacrylate, 2-hydroxypropyl methacrylate, 2,2,2-trifluoroethyl methacrylate, 2,2,2-trichloroethyl methacrylate, 2-bromoethyl methacrylate, 4-hydroxybutyl methacrylate, 2-methoxyethyl methacrylate, tetrahydrofurfuryl methacrylate, 2-methyl-2-adamantyl methacrylate, 5-methacryloyloxy-6-hydroxynorbornene-2-carboxylic-6-lactone, 3-methacryloxypropyltriethoxysilane, glycidyl methacrylate, 2-phenylethyl methacrylate, hydroxyphenyl methacrylate, and bromophenyl methacrylate.

[0077]

Specific examples of the acrylamide compound include, but are not limited to, acrylamide, N-methylacrylamide, N-ethylacrylamide, N-benzylacrylamide, N-phenylacrylamide, N,N-dimethylacrylamide, and N-anthrylacrylamide.

[0078]

Specific examples of the methacrylamide compound include, but are not limited to, methacrylamide, N-methylmethacrylamide, N-ethylmethacrylamide, N-benzylmethacrylamide, N-phenylmethacrylamide, N,N-dimethylmethacrylamide, and N-anthrylmethacrylamide.

[0079]

Specific examples of the vinyl compound include, but are not limited to, vinyl alcohol, 2-hydroxyethyl vinyl ether, methyl vinyl ether, ethyl vinyl ether, benzyl vinyl ether, vinylacetic acid, vinyltrimethoxysilane, 2-

chloroethyl vinyl ether, 2-methoxyethyl vinyl ether, vinylnaphthalene, and vinylanthracene.

[0080]

Specific examples of the styrene compound include, but are not limited to, styrene, hydroxystyrene, chlorostyrene, bromostyrene, methoxystyrene, cyanostyrene, and acetylstyrene.

[0081]

In addition, the polymer (B) may be a polymer described in WO 2023/248946 A.

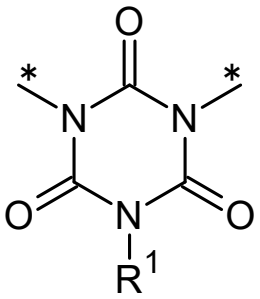
The contents of this publication are incorporated herein in their entirety as if fully set forth.

[0082]

<<<Polymer (C)>>>

The polymer (C) is a polymer containing a structure represented by formula (1) below.

[Chem. 25]



(1)

In formula (1), R^1 represents a hydrogen atom, a protecting group of an imide group deprotected by an alkali, or a protecting group of an imide group deprotected

by an acid, and * represents a bonding site.

[0083]

Examples of the protecting group of an imide group that is deprotected by an alkali in R^1 include a methyl group, a cyclohexyl group, a hydroxyethyl group, a benzyl group, and a phenyl group.

Examples of the protecting group of an imide group deprotected by an acid in R^1 include a tert-butoxycarbonyl group, a benzyloxycarbonyl group, a trimethylsilyl group, a tert-butyldimethylsilyl group, a methoxymethyl group, an ethoxymethyl group, a tetrahydropyranyl group, an acetyl group, a benzyl group, and a p-methoxybenzyl group.

Examples of the alkali include alkalis contained in alkaline removing liquids.

Examples of the acid include acids contained in acidic removing liquids.

[0084]

The deprotection of the protecting group of an imide group deprotected by the alkali can be performed, for example, when the coating film formed from the composition for forming a coating film for removing foreign matters is brought into contact with an alkaline removing liquid.

The deprotection of the protecting group of an imide group deprotected by the acid can be performed, for example, when the coating film formed from the composition

for forming a coating film for removing foreign matters is brought into contact with an acidic removing liquid.

When a coating film is formed from a composition for forming a coating film for removing foreign matters containing an acid generator, the deprotection of the protecting group of an imide group deprotected by the acid can be performed, for example, using an acid generated from the acid generator.

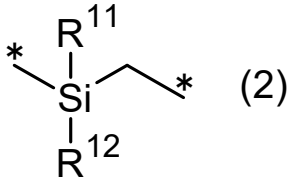
[0085]

R^1 in formula (1) is preferably a hydrogen atom.

[0086]

The polymer (C) preferably further contains a structure represented by the following formula (2).

[Chem. 26]



(2)

In formula (2), R^{11} and R^{12} each independently represent an optionally substituted alkyl group having 1 to 10 carbon atoms, an optionally substituted phenyl group, or an optionally substituted phenoxy group, and * represents a bonding site.

[0087]

Examples of the substituent in the optionally substituted alkyl group having 1 to 10 carbon atoms in the

present invention include a halogen atom, a hydroxy group, and a carboxy group.

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

Examples of the optionally substituted alkyl group having 1 to 10 carbon atoms include an alkyl group having 1 to 10 carbon atoms.

[0088]

Examples of the substituents in the optionally substituted phenyl group and the optionally substituted phenoxy group in the present invention include a halogen atom, an alkyl group having one to six carbon atoms that may be substituted with a halogen atom, and an alkoxy group having one to six carbon atoms that may be substituted with a halogen atom.

The number of substituents in the phenyl group and the phenoxy group may be one or may be two or more.

When the number of substituents in the phenyl group and the phenoxy group is two or more, they may be the same type of substituents or different types of substituents.

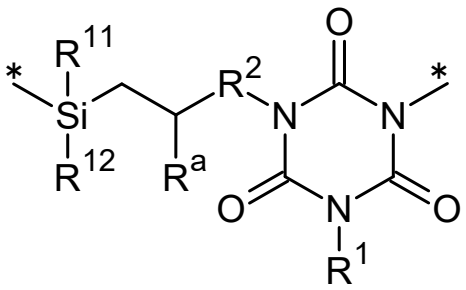
[0089]

As R^{11} and R^{12} in formula (2), an alkyl group having 1 to 10 carbon atoms is preferable, an alkyl group having 1 to 6 carbon atoms is more preferable, and a methyl group is particularly preferable.

[0090]

For example, in the polymer (C), the structure represented by formula (1) and the structure represented by formula (2) are linked as in the structure represented by formula (11) below. In other words, the polymer (C) contains, for example, a structure represented by formula (11) below.

[Chem. 27]



(11)

In formula (11), R^1 represents a hydrogen atom, a protecting group of an imide group deprotected by an alkali, or a protecting group of an imide group deprotected by an acid.

R^2 represents a divalent group having 1 to 6 carbon atoms.

R^{11} and R^{12} each independently represent an optionally substituted alkyl group having 1 to 10 carbon atoms, an optionally substituted phenyl group, or an optionally substituted phenoxy group.

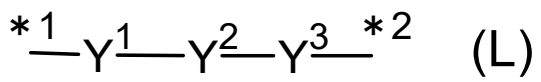
R^a represents a hydrogen atom or a methyl group.

* represents a bonding site.

[0091]

Examples of R^2 in formula (11) include a divalent group represented by formula (L) below.

[Chem. 28]



In formula (L), Y^1 represents a single bond or an alkylene group having 1 to 6 carbon atoms.

Y^2 represents a single bond, -C(=O)-, -O-, -C(=O)O-, -OC(=O)-, or $-OCH_2CH(OH)-$.

Y^3 represents a single bond or an alkylene group having 1 to 6 carbon atoms.

*1 represents a bonding site to a carbon atom.

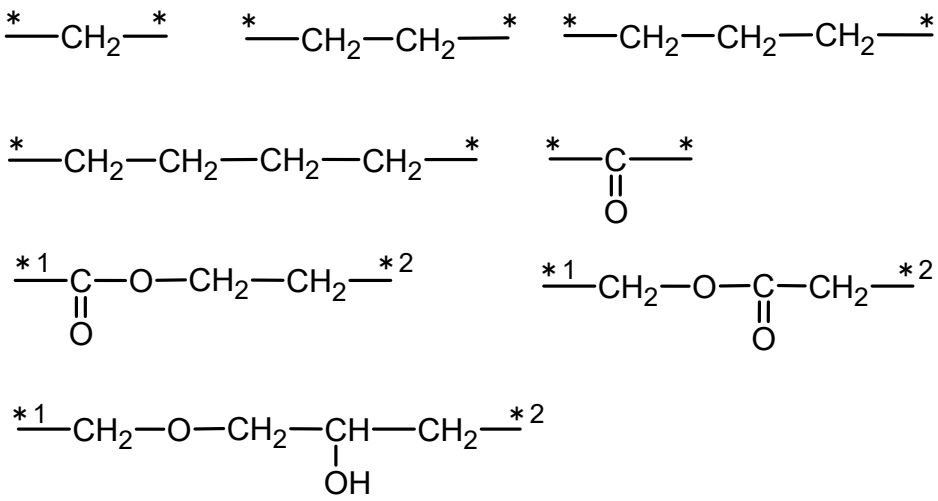
*2 represents a bonding site to a nitrogen atom.

Provided that the total number of carbon atoms of Y^1, Y^2, and Y^3 is 1 to 6.

[0092]

Examples of the divalent group represented by formula (L) include the following groups.

[Chem. 29]



In the formula, * represents a bonding site. *1 represents a bonding site to a carbon atom. *2 represents a bonding site to a nitrogen atom.

[0093]

Examples of the alkylene group having one to six carbon atoms in the present invention include a methylene group, a 1,2-ethylene group, a 1,3-propylene group, a 1,2-propylene group, a 1,4-butylene group, a 1,5-pentylene group, and a 1,6-hexylene group.

[0094]

R^2 in formula (11) is preferably a methylene group.

As R^{11} and R^{12} in formula (11), an alkyl group having 1 to 10 carbon atoms and an optionally substituted phenyl group are preferable, an alkyl group having 1 to 6 carbon atoms and a phenyl group are more preferable, and a methyl group and a phenyl group are particularly preferable.

[0095]

The polymer (C) is preferably a polymer obtained by a hydrosilylation reaction between a compound having a Si-H group and a compound having a carbon-carbon unsaturated bond capable of a hydrosilylation reaction.

[0096]

The hydrosilylation reaction is performed, for example, in the presence of a platinum group metal-based catalyst.

Such a platinum-based metal catalyst is a catalyst for promoting a hydrosilylation reaction between a Si-H group of a compound having a Si-H group and a carbon-carbon unsaturated bond (such as a carbon-carbon double bond) of a compound having a carbon-carbon unsaturated bond.

[0097]

Specific examples of the platinum-based metal catalyst include, but are not limited to, platinum-based catalysts such as platinum black, platinum(IV) chloride, chloroplatinic acid, a reaction product of chloroplatinic acid and monohydric alcohol, a complex of chloroplatinic acid and olefins, and platinum bisacetoacetate.

Examples of the complex of platinum and an olefin include, but are not limited to, a complex (such as Karstedt's catalyst) of divinyltetramethyldisiloxane and platinum.

The amount of the platinum group metal-based catalyst in the hydrosilylation reaction is not particularly

limited.

[0098]

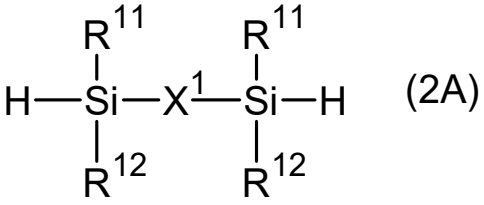
-Compound having Si-H group-

The compound having a Si-H group is not particularly limited as long as it is a compound having at least one Si-H group.

The number of Si-H groups in the compound having a Si-H group may be one or may be two or more.

The compound having a Si-H group is preferably a compound represented by formula (2A) below, a cyclic siloxane compound represented by formula (2B) below, or a silsesquioxane having a Si-H group.

[Chem. 30]

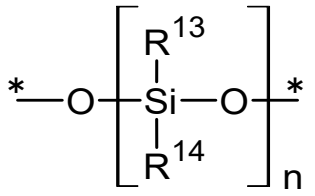


(2A)

In formula (2A), R^{11} and R^{12} each independently represent an optionally substituted alkyl group having 1 to 10 carbon atoms, an optionally substituted phenyl group, or an optionally substituted phenoxy group.

X^1 represents a single bond, an organic group having 1 to 10 carbon atoms, or a group represented by formula (2A-1) below.

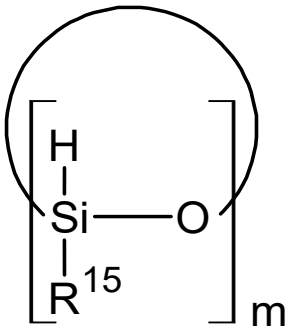
[Chem. 31]



(2A-1)

In formula (2A-1), R^{13} and R^{14} each independently represent an optionally substituted alkyl group having 1 to 10 carbon atoms, an optionally substituted phenyl group, or an optionally substituted phenoxy group. n represents an integer of 0 to 10. * represents a bonding site.

[Chem. 32]



(2B)

In formula (2B), R^{15} each independently represents an optionally substituted alkyl group having 1 to 10 carbon atoms, an optionally substituted phenyl group, or an optionally substituted phenoxy group. m represents an integer of 3 to 6.

[0099]

As R^{11} and R^{12} in formula (2A), an alkyl group having 1 to 10 carbon atoms and an optionally substituted phenyl group are preferable, an alkyl group having 1 to 6 carbon atoms and a phenyl group are more preferable, and a methyl group and a phenyl group are particularly preferable.

[0100]

Examples of the organic group having 1 to 10 carbon atoms of X^1 in formula (2A) include an alkylene group having 1 to 6 carbon atoms and a phenylene group.

[0101]

As R^{13} and R^{14} in formula (2A-1), an alkyl group having 1 to 10 carbon atoms and an optionally substituted phenyl group are preferable, an alkyl group having 1 to 6 carbon atoms and a phenyl group are more preferable, and a methyl group and a phenyl group are particularly preferable.

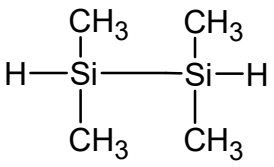
[0102]

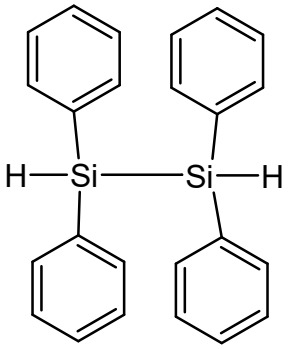
Examples of n in formula (2A-1) include 0, 1, 2, 3, and 4.

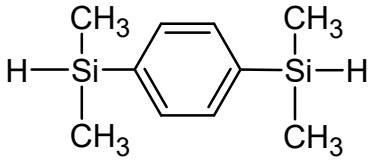
[0103]

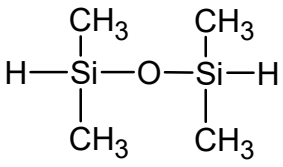
Examples of the compound represented by formula (2A) include the following compounds.

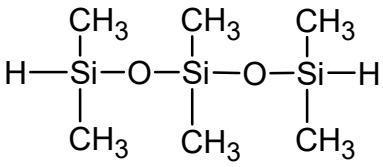
[Chem. 33]

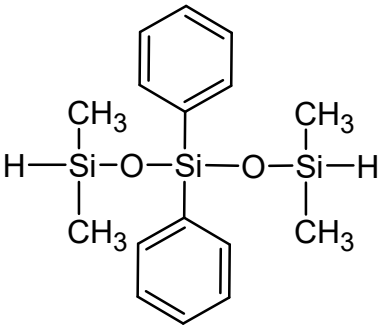


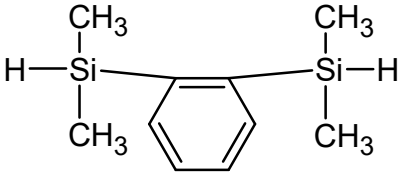












[0104]

As R^{15} in formula (2B), an alkyl group having 1 to 10 carbon atoms is preferable, an alkyl group having 1 to 6 carbon atoms is more preferable, and a methyl group is particularly preferable.

[0105]

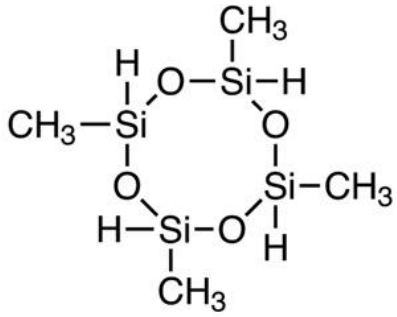
Examples of the cyclic siloxane compound represented by formula (2B) include 2,4,6-trimethylcyclotrisiloxane, 2,4,6,8,-tetramethylcyclotetrasiloxane, 2,4,6,8,10-pentamethylcyclopentasiloxane, 2,4,6,8,10,12-

hexamethylcyclohexasiloxane, and 2,4,6,8,10,12,14-heptamethylcycloheptasiloxane.

[0106]

2,4,6,8,-Tetramethylcyclotetrasiloxane is represented by the following formula.

[Chem. 34]



[0107]

A silsesquioxane is a network type polymer or polyhedral cluster obtained by hydrolyzing a trifunctional silane. As the silsesquioxane, silsesquioxanes having a random structure, a ladder structure, and a cage structure are known.

Examples of the cage structure include a closed cage structure and an open cage structure.

[0108]

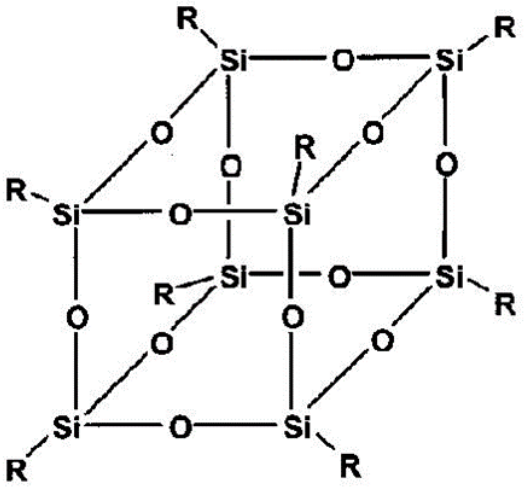
The number of Si-H groups in the silsesquioxane having a Si-H group may be one or may be two or more.

[0109]

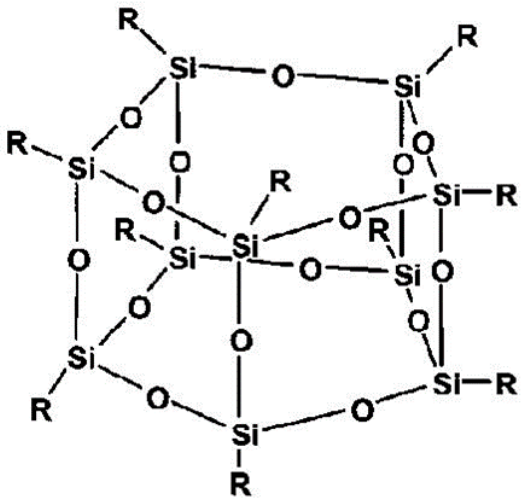
Examples of the silsesquioxane having a Si-H group

include cage-like silsesquioxanes represented by formulas (SQ1) to (SQ7) below.

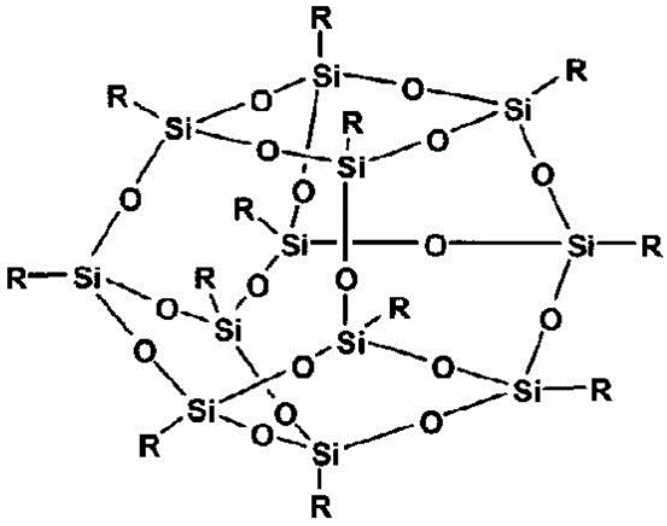
[Chem. 35]



(SQ1)

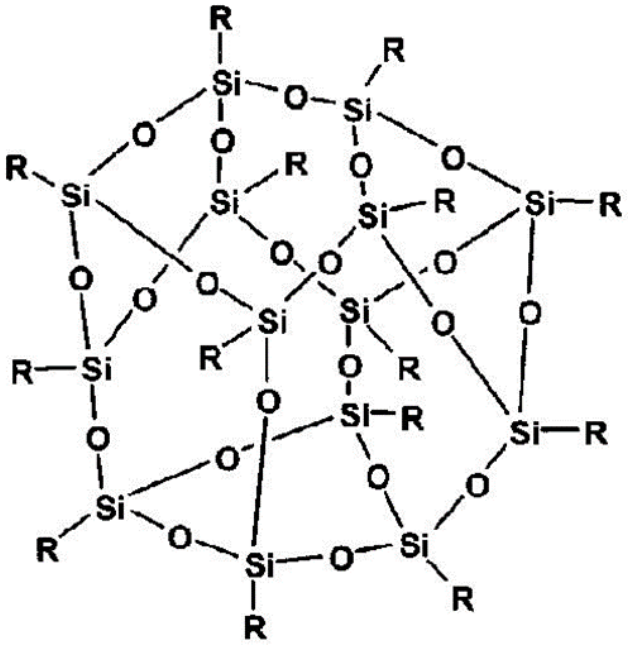


(SQ2)

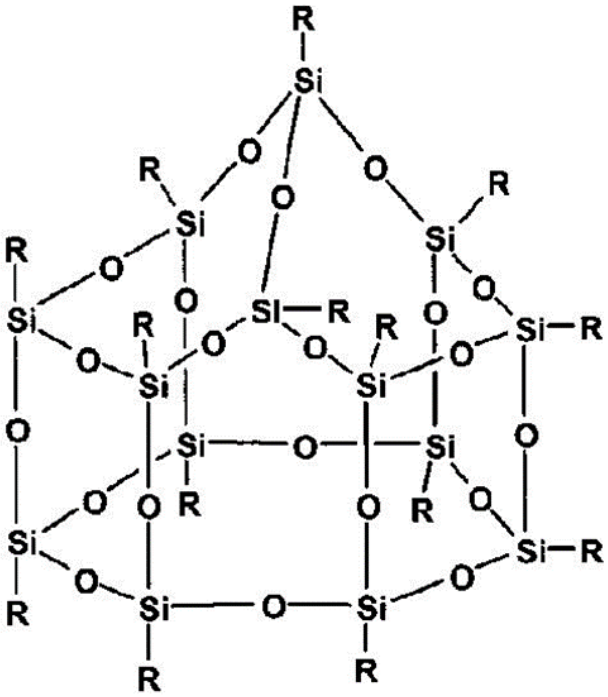


(SQ3)

[Chem. 36]

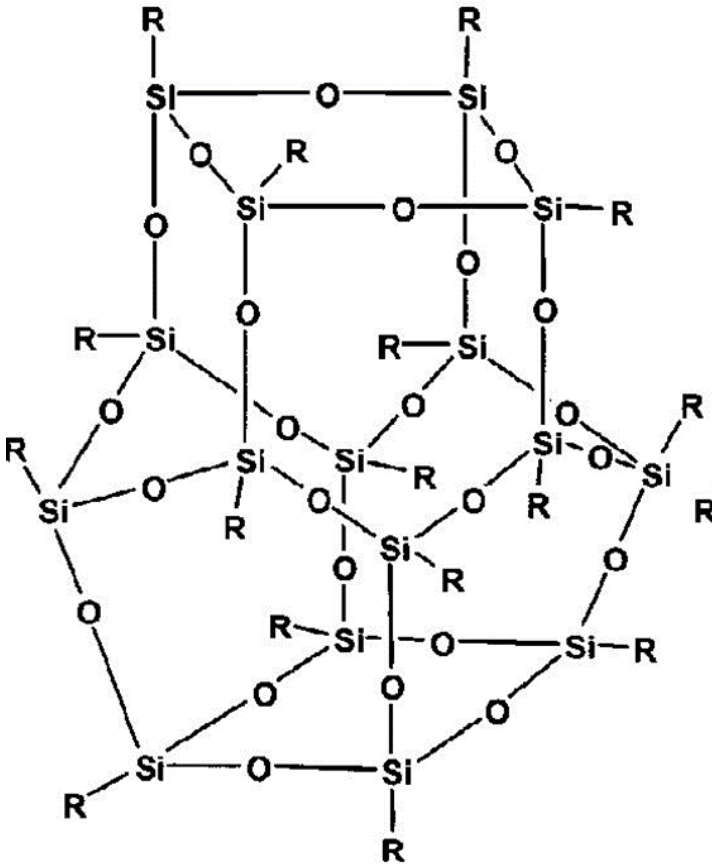


(SQ4)

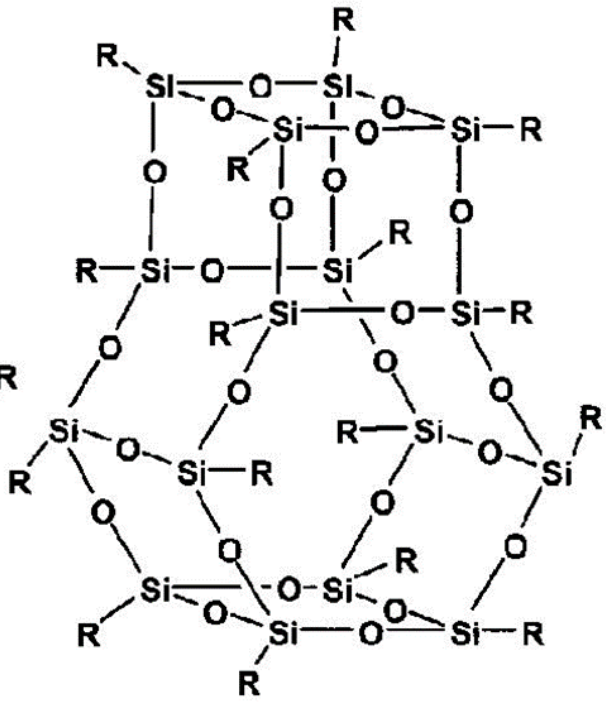


(SQ5)

[Chem. 37]



(SQ6)



(SQ7)

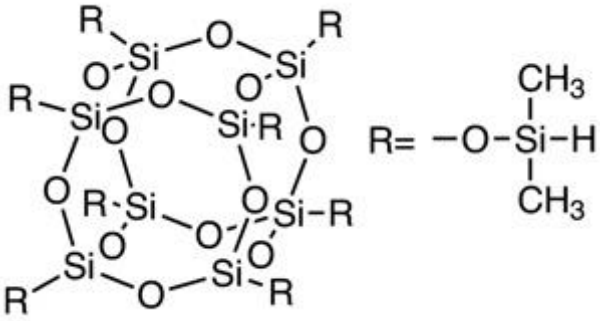
In formulas (SQ1) to (SQ7), R each independently represents a hydrogen atom, an alkyl group having 1 to 6 carbon atoms, a phenyl group, or -O-Si(R^{101})(R^{102})H (R^{101} and R^{102} each independently represent an alkyl group having 1 to 6 carbon atoms or a phenyl group).

However, each of formulas (SQ1) to (SQ7) has at least one Si-H group.

[0110]

Examples of the silsesquioxane having a Si-H group include the following compounds.

[Chem. 38]



[0111]

The molecular weight of the compound having a Si-H group is not particularly limited, but may be, for example, 100 to 1,500.

[0112]

-Compound having carbon-carbon unsaturated bond-

The compound having a carbon-carbon unsaturated bond has a carbon-carbon unsaturated bond that can undergo a hydrosilylation reaction. Examples of the carbon-carbon unsaturated bond that can undergo a hydrosilylation reaction include a carbon-carbon double bond and a carbon-carbon triple bond.

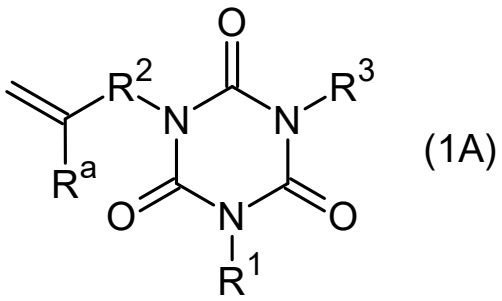
[0113]

The number of carbon-carbon unsaturated bonds that can undergo a hydrosilylation reaction in the compound having a carbon-carbon unsaturated bond is not particularly limited, but may be one or may be two or more.

[0114]

The compound having a carbon-carbon unsaturated bond preferably includes a compound represented by formula (1A) below.

[Chem. 39]



(1A)

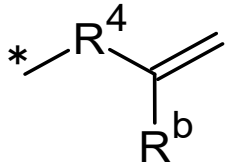
In formula (1A), R^1 represents a hydrogen atom, a protecting group of an imide group deprotected by an alkali, or a protecting group of an imide group deprotected by an acid.

R^2 represents a divalent group having 1 to 6 carbon atoms.

R^3 represents a hydrogen atom, a protecting group of an imide group deprotected by an alkali, a protecting group of an imide group deprotected by an acid, or a group represented by formula (1A-1) below.

R^a represents a hydrogen atom or a methyl group.

[Chem. 40]



(1A-1)

In formula (1A-1), R^4 represents a divalent group

having 1 to 6 carbon atoms. R^b represents a hydrogen atom or a methyl group. * represents a bonding site.

[0115]

Specific examples of the protecting group of an imide group deprotected by an alkali of R^1 and R^3 in formula (1A) include the specific examples of the protecting group of an imide group deprotected by an alkali of R^1 in formula (1).

Specific examples of the protecting group of an imide group deprotected by an acid of R^1 and R^3 in formula (1A) include the specific examples of the protecting group of an imide group deprotected by an acid of R^1 in formula (1).

[0116]

Examples of R^2 in formula (1A) include the divalent group represented by formula (L) above.

Specific examples of R^2 in formula (1A) include the specific examples mentioned in the description of R^2 in formula (11).

[0117]

Examples of R^4 in formula (1A-1) include the divalent group represented by formula (L) above.

Specific examples of R^4 in formula (1A-1) include the specific examples mentioned in the description of R^2 in formula (11).

[0118]

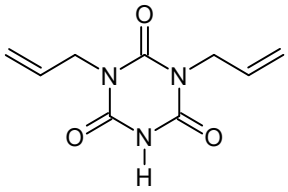
R^2 in formula (1A) is preferably a methylene group.

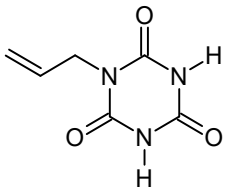
When R^3 in formula (1A) represents the group represented by formula (1A-1), R^4 in formula (1A-1) is preferably a methylene group.

[0119]

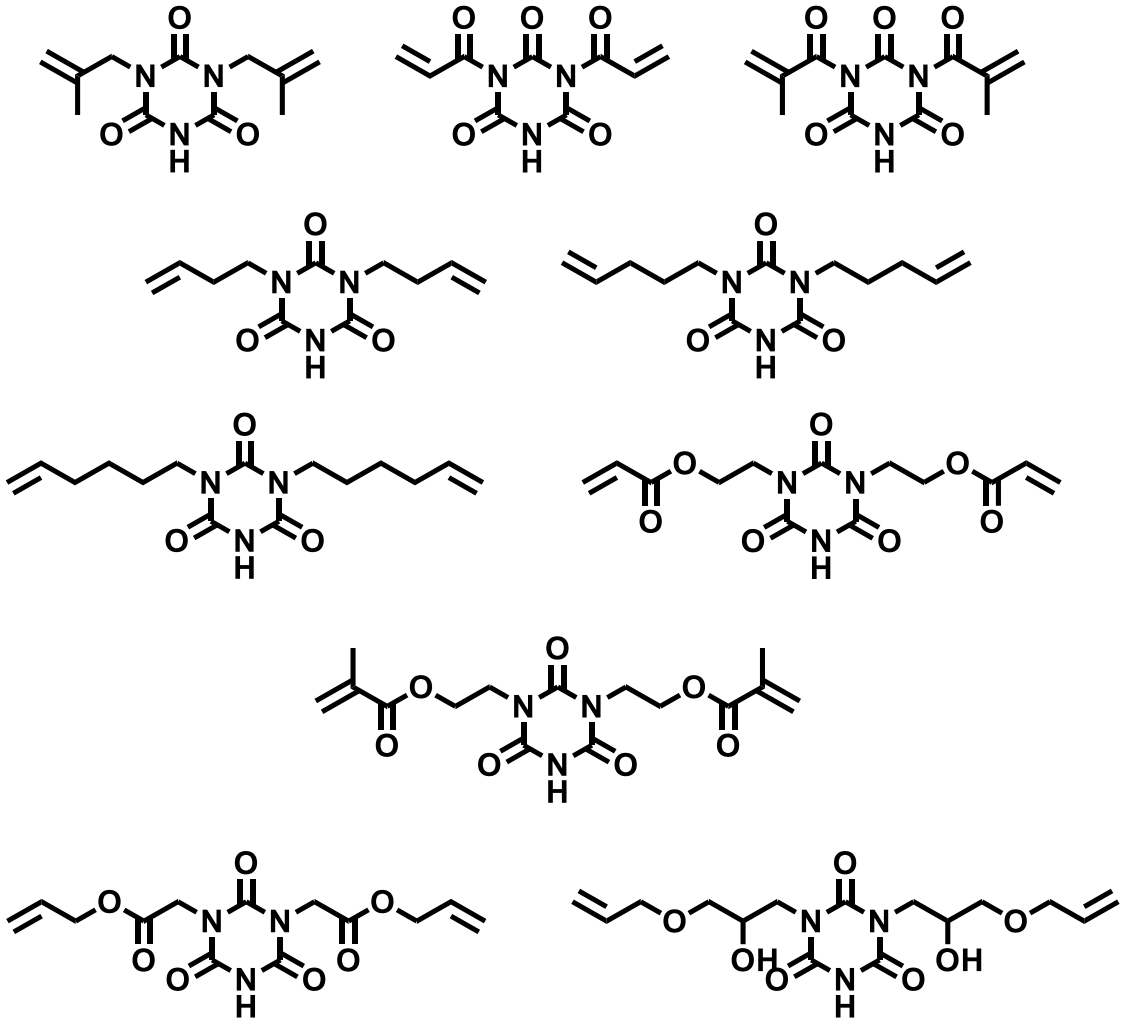
Examples of the compound represented by formula (1A) include the following compounds.

[Chem. 41]





[Chem. 42]



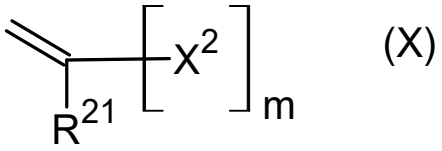
[0120]

When a polymer (C) is obtained using a hydrosilylation reaction, the compound having a carbon-carbon unsaturated bond may include a compound having a carbon-carbon unsaturated bond other than the compound represented by formula (1A), in addition to the compound represented by formula (1A).

Examples of the compound having a carbon-carbon unsaturated bond other than the compound represented by formula (1A) include a compound represented by formula (X)

below.

[Chem. 43]



(X)

In formula (X), R^{21} represents a hydrogen atom or a methyl group.

X^2 represents an m-valent organic group.

m represents an integer of 1 to 3.

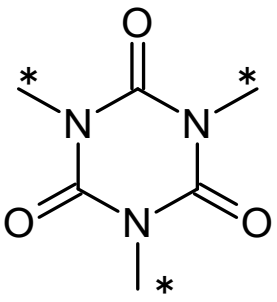
[0121]

The molecular weight of X^2 in formula (X) is not particularly limited, but is, for example, 100 to 500.

[0122]

X^2 in formula (X) does not have, for example, the following isocyanuric acid structure.

[Chem. 44]



In the formula, * represents a bonding site.

[0123]

The compound represented by formula (X) preferably has no ester bond from the viewpoint of heat resistance of the

polymer (C).

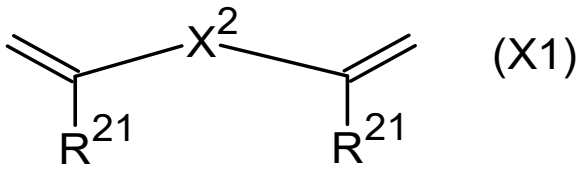
[0124]

X^2 in formula (X) preferably has an aromatic ring. The aromatic ring may be an aromatic hydrocarbon ring or may be an aromatic heterocyclic ring.

[0125]

Examples of the compound represented by formula (X) include a compound represented by formula (X1) below.

[Chem. 45]



(X1)

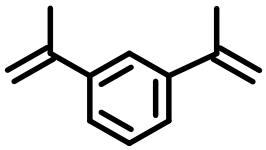
In formula (X1), R^{21} each independently represents a hydrogen atom or a methyl group.

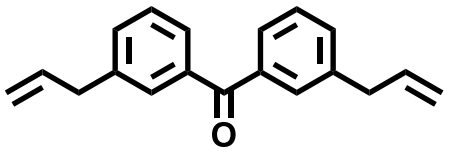
X^2 represents a divalent organic group having an aromatic ring.

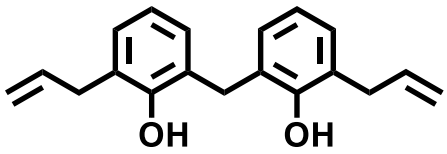
[0126]

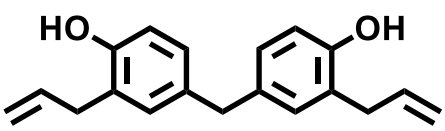
Examples of the compound represented by formula (X) include the following compounds.

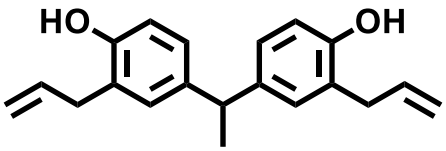
[Chem. 46]

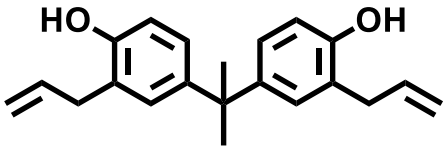


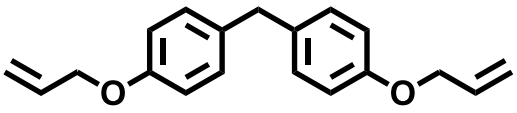


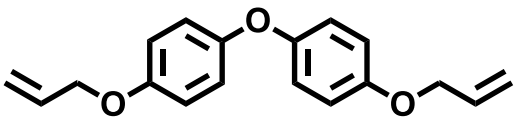


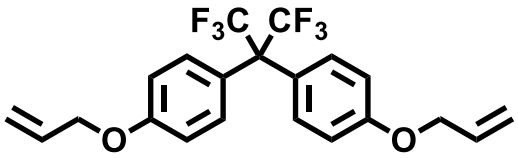


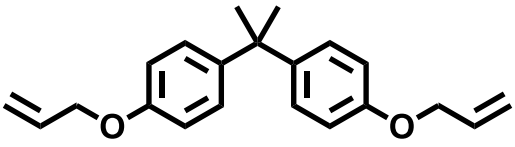


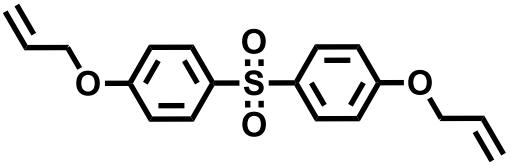


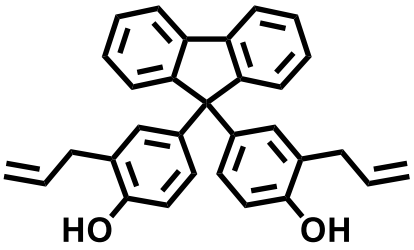


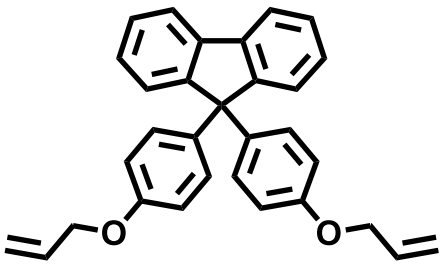










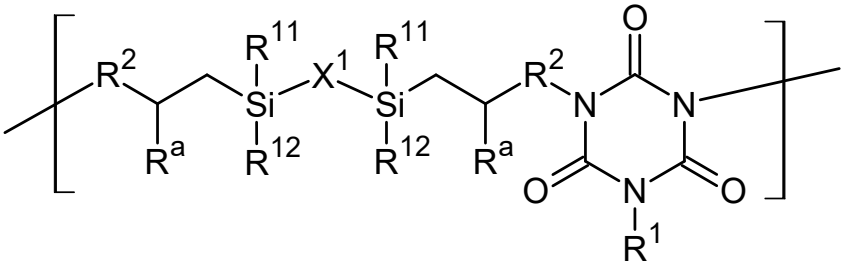


[0127]

The polymer (C) has, for example, a unit structure represented by formula (Y) below.

The polymer having the unit structure represented by formula (Y) is obtained, for example, by a hydrosilylation reaction between a compound having a Si-H group including the compound represented by formula (2A) and a compound having a carbon-carbon unsaturated bond including the compound represented by formula (1A).

[Chem. 47]



(Y)

In formula (Y), R^1 represents a hydrogen atom, a protecting group of an imide group deprotected by an alkali, or a protecting group of an imide group deprotected by an acid.

R^2 represents a divalent group having 1 to 6 carbon atoms.

R^{11} and R^{12} each independently represent an optionally substituted alkyl group having 1 to 10 carbon atoms, an optionally substituted phenyl group, or an optionally substituted phenoxy group.

R^a represents a hydrogen atom or a methyl group.

[0128]

R^1 in formula (Y) is as defined for R^1 in formulas (1) and (11).

R^2 in formula (Y) is as defined for R^2 in formula (11).

R^{11}, R^{12}, and X^1 in formula (Y) are as defined for R^{11} and R^{12} in formulas (2) and (2A) and X^1 in formula (2A), respectively.

[0129]

The weight average molecular weight of the polymer (C) is not particularly limited, and is preferably 1,000 to 50,000, and more preferably 1,500 to 30,000. The weight average molecular weight is a value obtained by gel permeation chromatography (GPC) using polystyrene as a standard sample.

[0130]

The polymer (C) may be a polymer described in WO 2024/117235 A [International Application (PCT/JP2023/42991)].

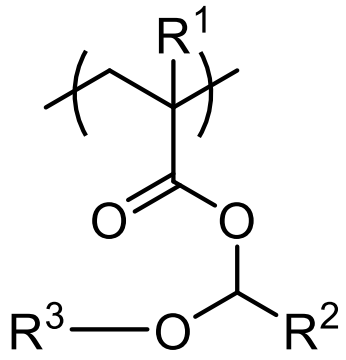
The contents of this application are incorporated herein in their entirety as if fully set forth.

[0131]

<<<Polymer (D)>>>

The polymer (D) is a polymer containing a structural unit represented by the following formula (1).

[Chem. 48]



(1)

In formula (1), R^1 represents a hydrogen atom or an alkyl group having 1 to 3 carbon atoms, R^2 represents a hydrogen atom or an alkyl group having 1 to 4 carbon atoms, R^3 represents an optionally substituted alkyl group having 1 to 10 carbon atoms or an optionally substituted aromatic hydrocarbon group, and R^2 and R^3 may form a ring together with a carbon atom and an oxygen atom between R^2 and R^3, and the ring may include a heteroatom in addition to the oxygen atom.

[0132]

Examples of the alkyl group having 1 to 3 carbon atoms in R^1 include a methyl group, an ethyl group, and a propyl group.

Examples of the alkyl group having 1 to 4 carbon atoms in R^2 include a methyl group, an ethyl group, a propyl group, and a butyl group.

Examples of the substituent in the optionally substituted alkyl group having 1 to 10 carbon atoms in R^3 include a halogen atom, an alkoxy group having 1 to 6

carbon atoms, and an aromatic group. Examples of the aromatic group include an aromatic hydrocarbon group. Examples of the aromatic hydrocarbon group include a phenyl group and a naphthyl group.

Examples of the substituent in the optionally substituted aromatic hydrocarbon group in R^3 include a halogen atom, an alkyl group having 1 to 6 carbon atoms, and an alkoxy group having 1 to 6 carbon atoms.

In the present invention, examples of the halogen atom include a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom.

[0133]

R^2 and R^3 may form a ring together with a carbon atom and an oxygen atom between R^2 and R^3, and the ring may include a heteroatom in addition to the oxygen atom.

Examples of the ring include a 4-membered ring to a 7-membered ring.

Examples of such a ring include a cyclic ether, a lactone ring, and a cyclic carbonate.

Examples of the heteroatom optionally included in the ring include an oxygen atom, a nitrogen atom, and a sulfur atom.

[0134]

R^1 is preferably a hydrogen atom or a methyl group.

R^2 is preferably a methyl group or an ethyl group.

R^3 is preferably an alkyl group having 1 to 6 carbon atoms, and more preferably an alkyl group having 1 to 4 carbon atoms.

[0135]

The present inventors consider that the acetal structure of formula (1) acts as a protecting group of a carboxy group, and improves the coatability of the composition for forming a coating film for removing foreign matters while imparting solubility in a solvent to the polymer (D).

Meanwhile, in the process of forming a coating film from the composition for forming a coating film for removing foreign matters, the acetal structure is desorbed (for example, thermal or catalytic desorption) to generate a carboxy group. The produced carboxy groups react with each other or react with the crosslinking agent in the presence of the crosslinking agent, thereby imparting solvent resistance to the coating film. Further, the produced carboxy groups facilitate the removal of the coating film by the removing liquid.

Therefore, the coating film obtained from the composition for forming a coating film for removing foreign matters exhibits favorable solvent resistance. In addition, the coating film obtained from the composition for forming a coating film for removing foreign matters can

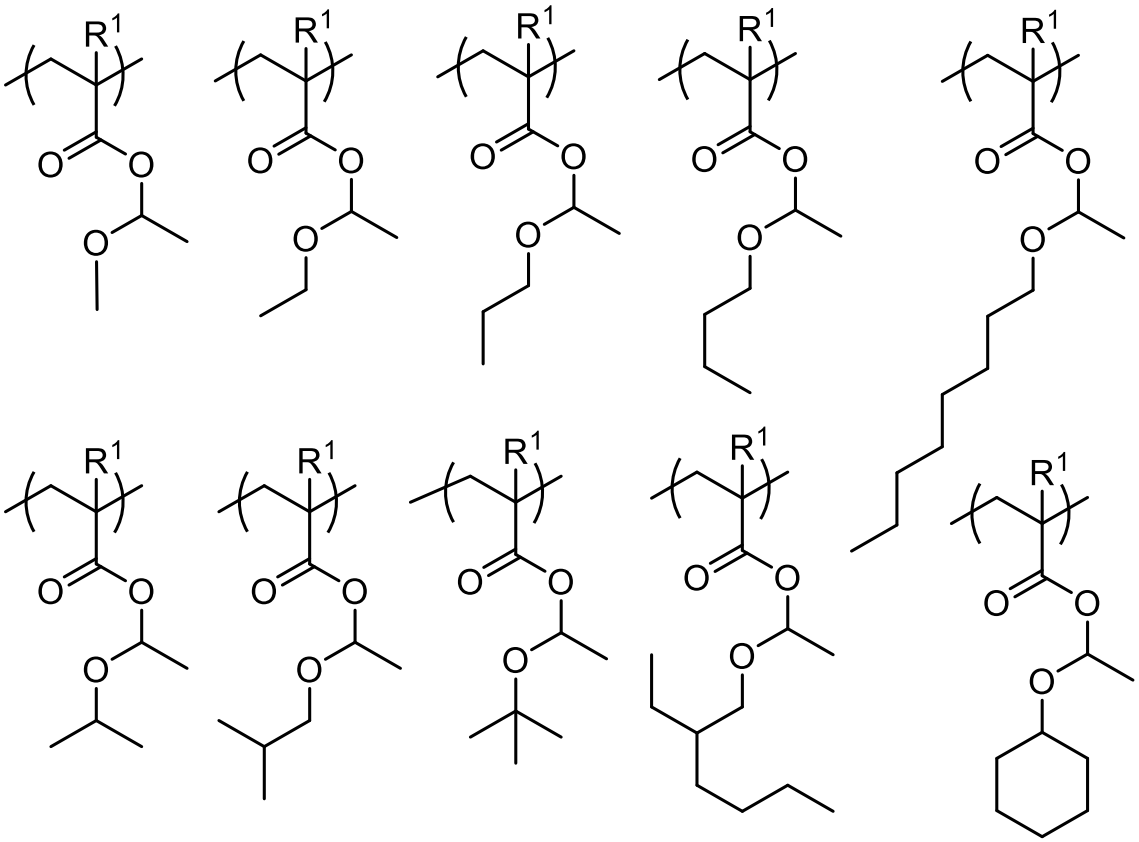
be removed by the removing liquid.

Therefore, the composition for forming a coating film for removing foreign matters of the present invention is a composition capable of preventing foreign matter from remaining on a substrate by a simple method, and is a composition from which a coating film having favorable solvent resistance and easy removability can be obtained.

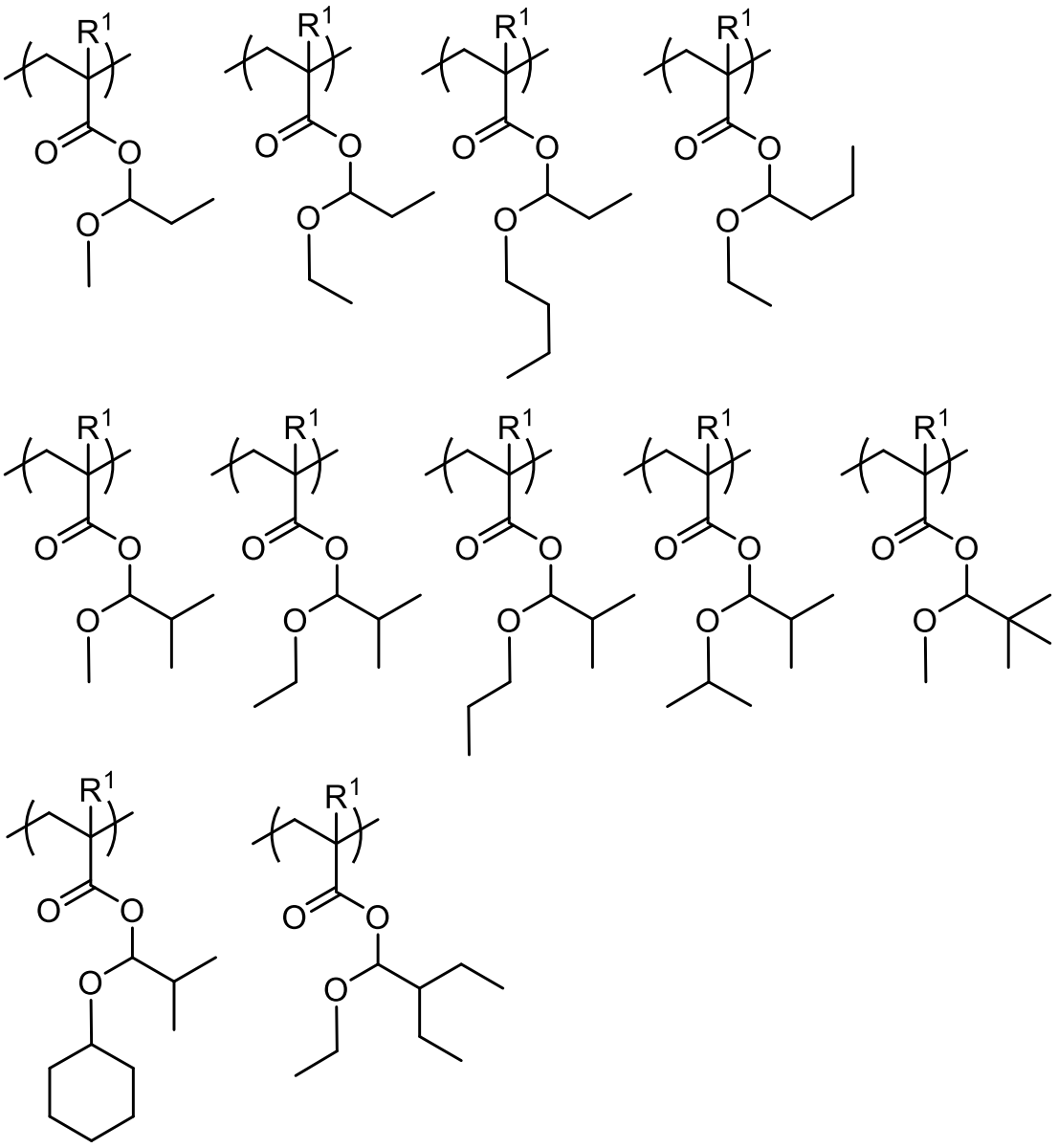
[0136]

Examples of the structural unit represented by formula (1) include the following structural units: In the following structural units, R^1 represents a hydrogen atom or an alkyl group having 1 to 3 carbon atoms, and preferably represents a hydrogen atom or a methyl group.

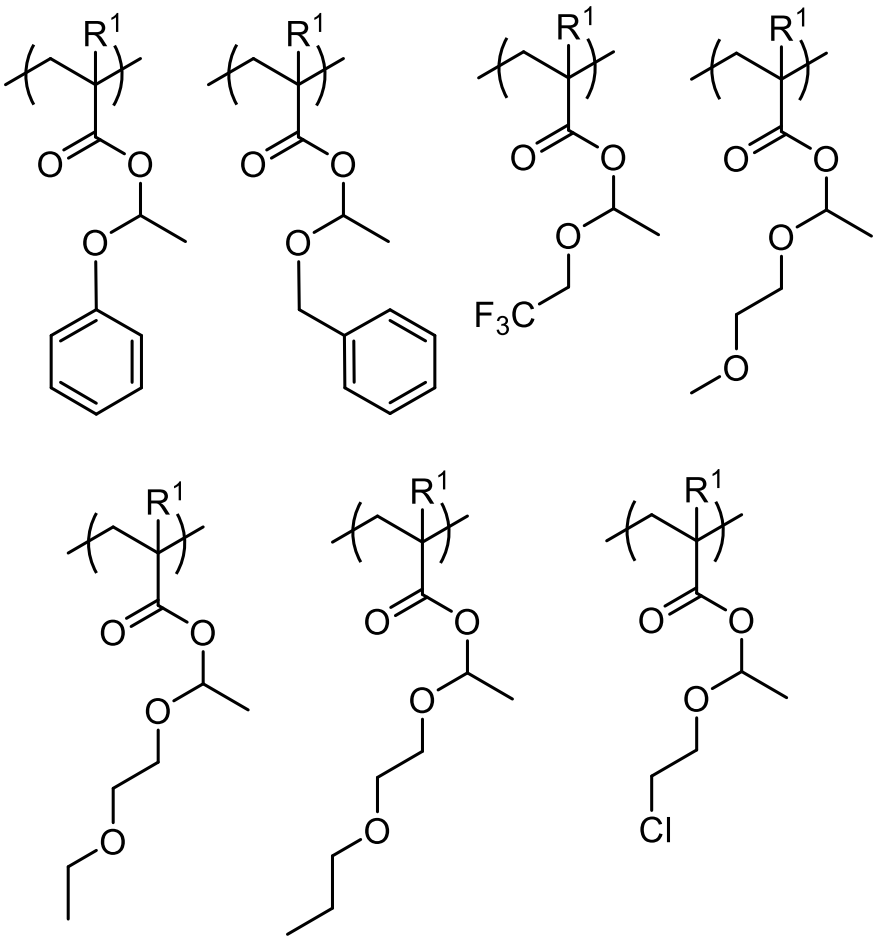
[Chem. 49]



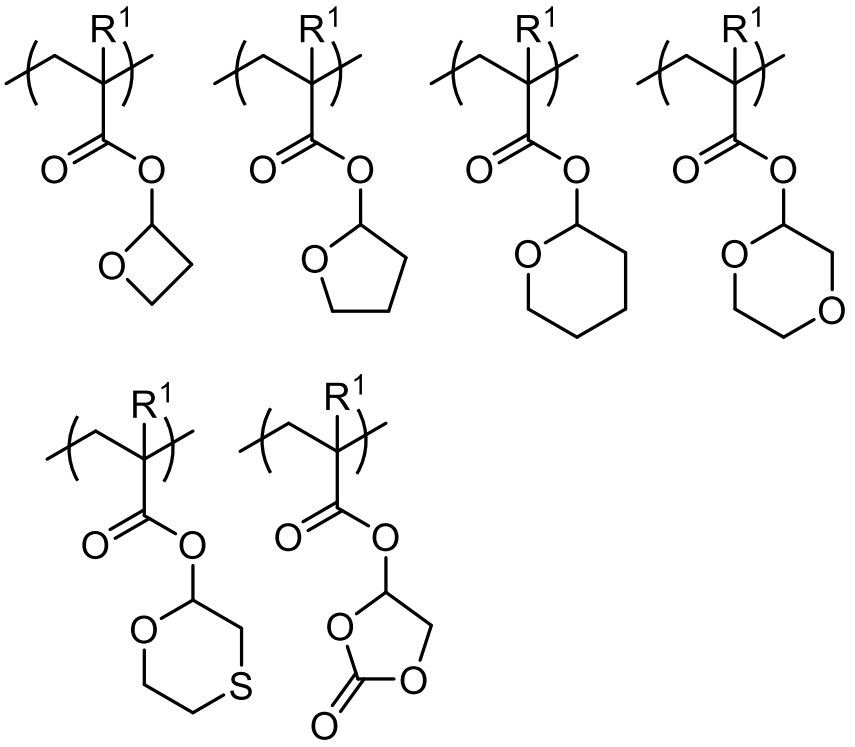
[Chem. 50]



[Chem. 51]



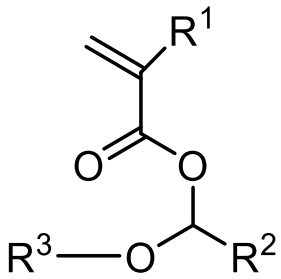
[Chem. 52]



[0137]

The structural unit represented by formula (1) is derived from, for example, a compound represented by the following formula (1A).

[Chem. 53]



(1A)

In formula (1A), R^1, R^2, and R^3 have the same meanings as R^1, R^2, and R^3 in formula (1), respectively.

[0138]

The polymer (D) may include a structural unit other

than the structural unit represented by formula (1).

Examples of such a structural unit include a structural unit derived from a (meth)acrylic acid ester compound, a (meth)acrylamide compound, or a styrene compound.

In the present invention, the (meth)acrylic acid ester compound means an acrylic acid ester compound or a methacrylic acid ester compound. The same applies to the (meth)acrylamide compound.

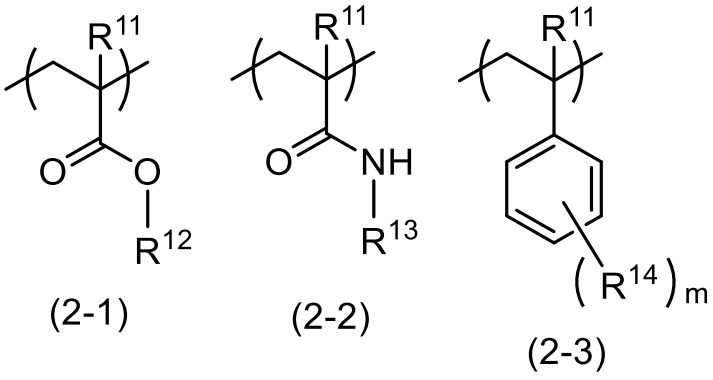
[0139]

Examples of the structural unit derived from the (meth)acrylic acid ester compound include a structural unit represented by the following formula (2-1).

Examples of the structural unit derived from the (meth)acrylamide compound include a structural unit represented by the following formula (2-2).

Examples of the structural unit derived from a styrene compound include a structural unit represented by the following formula (2-3).

[Chem. 54]



In formulas (2-1) to (2-3), R^{11} represents a hydrogen atom or an alkyl group having 1 to 3 carbon atoms, and R^{12} represents a monovalent group having 1 to 20 carbon atoms. R^{13} represents a hydrogen atom or a monovalent group having 1 to 20 carbon atoms. R^{14} each independently represents a halogen atom, a hydroxy group, a carboxy group, a cyano group, a nitro group, or a monovalent group having 1 to 10 carbon atoms. m represents an integer of 0 to 5.

[0140]

The number of carbon atoms in R^{12} and R^{13} may be 1 to 20 or 1 to 10.

The monovalent group having 1 to 20 carbon atoms in R^{12} and R^{13} may have a heteroatom. Examples of the heteroatom include an oxygen atom and a nitrogen atom.

The monovalent group having 1 to 20 carbon atoms in R^{12} and R^{13} may have an aromatic ring. Examples of the aromatic ring include an aromatic hydrocarbon ring and an aromatic heterocyclic ring. Examples of the aromatic hydrocarbon ring include a benzene ring and a naphthalene ring.

The monovalent group having 1 to 20 carbon atoms in R^{12} and R^{13} may have, for example, a halogen atom, a hydroxy group, a carboxy group, a cyano group, a nitro group, an epoxy group, or the like.

Examples of the monovalent group having 1 to 20 carbon atoms in R^{12} and R^{13} include an optionally substituted alkyl

group and an optionally substituted aromatic group.

Examples of the substituent in the optionally substituted alkyl group include a halogen atom, a hydroxy group, a carboxy group, a cyano group, a nitro group, an epoxy group, and an optionally substituted aromatic group.

Examples of the substituent in the aromatic group optionally substituted include a halogen atom, a hydroxy group, a carboxy group, a cyano group, a nitro group, an epoxy group, an alkyl group having 1 to 6 carbon atoms optionally substituted with a halogen atom, and an alkoxy group having 1 to 6 carbon atoms which may be substituted with a halogen atom.

Examples of the alkyl group having 1 to 6 carbon atoms include a methyl group, an ethyl group, a propyl group, and a butyl group.

Examples of the alkoxy group having 1 to 6 carbon atoms include a methoxy group, an ethoxy group, a propoxy group, and a butoxy group.

[0141]

The monovalent group having 1 to 10 carbon atoms in R^{14} may have a heteroatom. Examples of the heteroatom include an oxygen atom and a nitrogen atom.

The monovalent group having 1 to 10 carbon atoms in R^{14} may have, for example, a halogen atom, a hydroxy group, a carboxy group, a cyano group, a nitro group, an epoxy

group, or the like.

Examples of the monovalent group having 1 to 10 carbon atoms in R^{14} include an alkyl group having 1 to 6 carbon atoms optionally substituted with a halogen atom, and an alkoxy group having 1 to 6 carbon atoms optionally substituted with a halogen atom.

Examples of the alkyl group having 1 to 6 carbon atoms include a methyl group, an ethyl group, a propyl group, and a butyl group.

Examples of the alkoxy group having 1 to 6 carbon atoms include a methoxy group, an ethoxy group, a propoxy group, and a butoxy group.

[0142]

Specific examples of the acrylic acid ester compound include, but are not limited to, methyl acrylate, ethyl acrylate, n-hexyl acrylate, i-propyl acrylate, cyclohexyl acrylate, benzyl acrylate, phenyl acrylate, 4-hydroxyphenyl acrylate, anthrylmethyl acrylate, 2,2,2-trifluoroethyl acrylate, 2,2,2-trichloroethyl acrylate, 2-bromoethyl acrylate, 2-methoxyethyl acrylate, tetrahydrofurfuryl acrylate, 2-methyl-2-adamantyl acrylate, 3-acryloxypropyltriethoxysilane, and glycidyl acrylate.

[0143]

Specific examples of the methacrylic acid ester compound include, but are not limited to, methyl

methacrylate, ethyl methacrylate, n-hexyl methacrylate, i-propyl methacrylate, cyclohexyl methacrylate, benzyl methacrylate, phenyl methacrylate, 4-hydroxyphenyl acrylate, anthrylmethyl methacrylate, 2,2,2-trifluoroethyl methacrylate, 2,2,2-trichloroethyl methacrylate, 2-bromoethyl methacrylate, 2-methoxyethyl methacrylate, tetrahydrofurfuryl methacrylate, 2-methyl-2-adamantyl methacrylate, 3-methacryloxypropyltriethoxysilane, glycidyl methacrylate, 2-phenylethyl methacrylate, and bromophenyl methacrylate.

[0144]

Specific examples of the acrylamide compound include, but are not limited to, acrylamide, N-methylacrylamide, N-ethylacrylamide, N-benzylacrylamide, N-phenylacrylamide, N-(4-hydroxyphenyl)acrylamide, N,N-dimethylacrylamide, and N-anthrylacrylamide.

[0145]

Specific examples of the methacrylamide compound include, but are not limited to, methacrylamide, N-methylmethacrylamide, N-ethylmethacrylamide, N-benzylmethacrylamide, N-phenylmethacrylamide, N-(4-hydroxyphenyl)methacrylamide, N,N-dimethylmethacrylamide, and N-anthrylmethacrylamide.

[0146]

Specific examples of the styrene compound include, but

are not limited to, styrene, chlorostyrene, bromostyrene, methoxystyrene, cyanostyrene, and acetylstyrene.

[0147]

The polymer (D) may further have other structural units. Examples of the monomers from which such a structural unit is derived include, but are not limited to, acrylic acid, methacrylic acid, a vinyl compound, a maleimide compound, maleic anhydride, and acrylonitrile.

[0148]

Specific examples of the vinyl compound include, but are not limited to, vinyl alcohol, 2-hydroxyethyl vinyl ether, methyl vinyl ether, ethyl vinyl ether, benzyl vinyl ether, vinylacetic acid, vinyltrimethoxysilane, 2-chloroethyl vinyl ether, 2-methoxyethyl vinyl ether, vinylnaphthalene, and vinylanthracene.

[0149]

Examples of the maleimide compound include, but are not limited to, maleimide, N-methylmaleimide, N-phenylmaleimide, N-cyclohexylmaleimide, N-benzylmaleimide, and N-hydroxyethylmaleimide.

[0150]

The lower limit value of the molar ratio of the structural unit represented by formula (1) based on all structural units of the polymer (D) is not particularly limited, but from the viewpoint of suitably obtaining the

effect of the present invention, the molar ratio of the structural unit represented by formula (1) is preferably 20 mol% or more, more preferably 45 mol% or more, and particularly preferably 65 mol or more.

The upper limit value of the molar ratio of the structural unit represented by formula (1) based on all structural units of the polymer (D) is not particularly limited, but from the viewpoint of suitably obtaining the effect of the present invention, the molar ratio of the structural unit represented by formula (1) is preferably 100 mol% or less, more preferably 95 mol% or less, and particularly preferably 90 mol% or less.

[0151]

The lower limit value of the molar ratio of the total of structural units derived from a (meth)acrylic acid ester compound, structural units derived from a (meth)acrylamide compound, and structural units derived from a styrene compound (hereinafter sometimes referred to as “total structural unit (2)”) based on all structural units of the polymer (D) is not particularly limited, but from the viewpoint of suitably obtaining the effect of the present invention, the molar ratio of the total structural unit (2) is preferably more than 0 mol%, and more preferably 10 mol% or more.

The upper limit value of the molar ratio of the total

structural unit (2) based on all structural units of the polymer is not particularly limited, but from the viewpoint of suitably obtaining the effect of the present invention, the molar ratio of the total structural unit (2) is preferably 60 mol% or less, and more preferably 45 mol% or less.

[0152]

The molar ratio of the sum of the structural unit represented by formula (1) and the total structural unit (2) based on all structural units of the polymer (D) is not particularly limited, but is preferably 80 mol% to 100 mol%, and more preferably 90 mol% to 100 mol% from the viewpoint of suitably obtaining the effect of the present invention.

[0153]

The polymer (D) may be a homopolymer or a copolymer. When the polymer is a copolymer, the polymer may be a random copolymer or a block copolymer.

[0154]

The method for producing the polymer (D) is not particularly limited.

The polymer (D) can be produced by polymerizing a monomer by a conventional method, for example, bulk polymerization, solution polymerization, suspension polymerization, or emulsion polymerization. Solution

polymerization is particularly preferred, in which case, for example, a polymerization initiator can be used to polymerize the monomer.

As the polymerization initiator, an organic peroxide or a diazo-based compound can be used.

[0155]

The weight-average molecular weight of the polymer (D) is not particularly limited, and is preferably 5,000 to 75,000, and more preferably 10,000 to 50,000. The weight average molecular weight is a value obtained by gel permeation chromatography (GPC) using polystyrene as a standard sample.

[0156]

The polymer (D) may be a polymer described in Japanese Patent Application No. 2024-3840 and International Application PCT/JP2025/258.

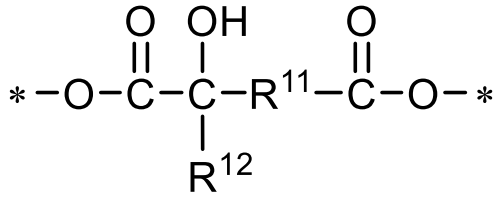
The contents of this application are incorporated herein in their entirety as if fully set forth.

[0157]

<<<Polymer (E)>>>

The polymer (E) has a partial structure represented by the following formula (A).

[Chem. 55]



(A)

In formula (A), R^{11} represents a single bond or a divalent group having 1 to 4 carbon atoms. R^{12} represents a hydrogen atom, a hydroxy group, or a methyl group. * represents a bonding site.

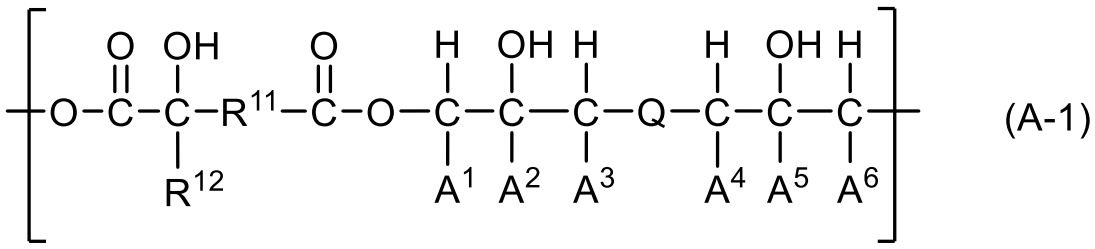
[0158]

When the polymer (E) has the partial structure represented by formula (A), the solvent resistance and easy removability are imparted to a coating film obtained from the composition for forming a coating film for removing foreign matters.

[0159]

The polymer (E) preferably has a structural unit represented by the following formula (A-1). For example, the partial structure represented by formula (A) is a part of a structural unit represented by the following formula (A-1).

[Chem. 56]



(A-1)

In formula (A-1), A^1, A^2, A^3, A^4, A^5, and A^6 each independently represent a hydrogen atom, a methyl group or an ethyl group, and Q represents a divalent organic group. R^{11} represents a single bond or a divalent group having 1 to 4 carbon atoms. R^{12} represents a hydrogen atom, a hydroxy group, or a methyl group.

[0160]

<<R^{11}>>

In formulas (A) and (A-1), R^{11} represents a single bond or a divalent group having 1 to 4 carbon atoms.

The number of carbon atoms that R^{11} has is 1 to 4, and may be 1 to 3, 1 or 2, or 1.

Examples of R^{11} include a divalent hydrocarbon group having 1 to 4 carbon atoms optionally substituted with a hydroxy group.

When R^{11} has a hydroxy group, the number of hydroxy groups of R^{11} is, for example, equal to or less than the number of carbon atoms of R^{11}.

R^{11} represents a divalent group having 1 to 4 carbon atoms, and the divalent group preferably has a hydroxy group, from the viewpoint of suitably obtaining the effect of the present invention.

R^{11} more preferably represents -CH(OH)- from the viewpoint of suitably obtaining the effect of the present invention.

[0161]

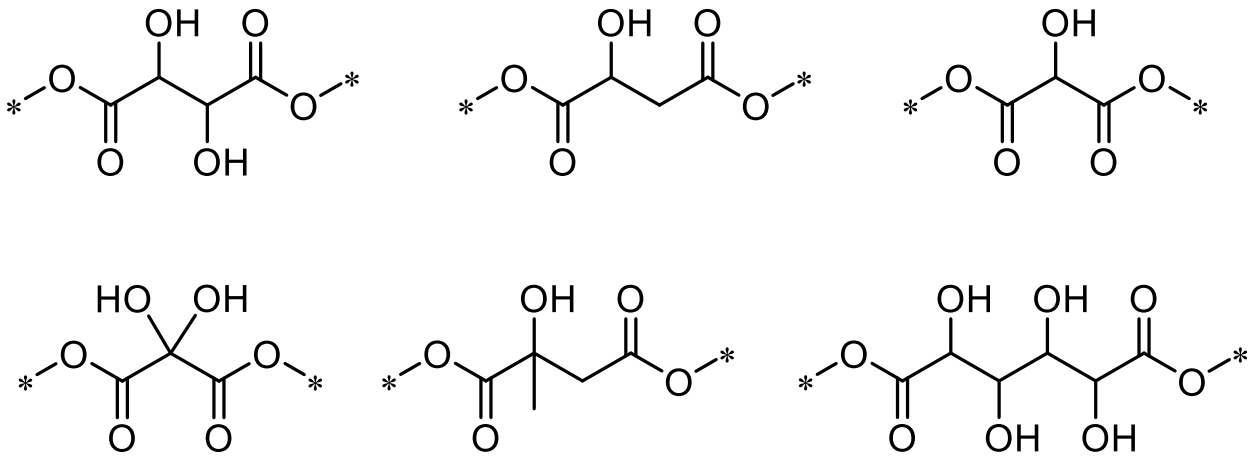
<<R^{12}>>

In formulas (A) and (A-1), R^{12} represents a hydrogen atom, a hydroxy group, or a methyl group, and preferably represents a hydrogen atom or a hydroxy group.

[0162]

Examples of the partial structure represented by formula (A) include the following structures.

[Chem. 57]



* represents a bonding site.

[0163]

<<Q>>

In formula (A-1), Q represents a divalent organic group. The divalent organic group is not particularly limited, but is preferably a divalent organic group having a hetero atom, and more preferably a divalent organic group having a nitrogen atom and an oxygen atom. Examples of the hetero atom include a nitrogen atom, an oxygen atom, and a

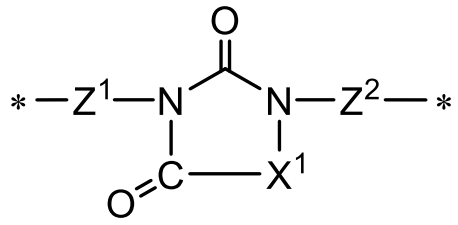
sulfur atom.

The number of carbon atoms of the divalent organic group is not particularly limited, but the number of carbon atoms is preferably 3 to 30, and more preferably 3 to 20.

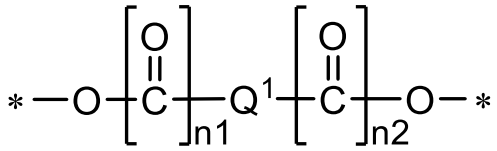
[0164]

Q is preferably represented by any one of the following formulas (A-11) and (A-12) from the viewpoint of suitably obtaining the effect of the present invention.

[Chem. 58]



(A-11)



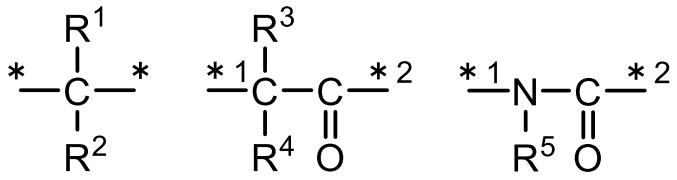
(A-12)

In formula (A-11), X^1 represents a divalent group represented by the following formula (A-11-1), the following formula (A-11-2), or the following formula (A-11-3). Z^1 and Z^2 each independently represent a single bond or a divalent group represented by the following formula (A-11-4). * represents a bonding site.

In formula (A-12), Q^1 represents a divalent group having an aromatic hydrocarbon ring or an aliphatic hydrocarbon ring. n1 and n2 each independently represent 0

or 1. * represents a bonding site.

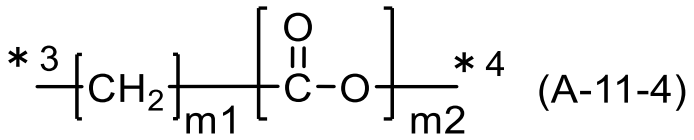
[Chem. 59]



(A-11-1) (A-11-2) (A-11-3)

In formulas (A-11-1) to (A-11-3), R^1 to R^5 each independently represent a hydrogen atom, an alkyl group having 1 to 10 carbon atoms optionally interrupted by an oxygen atom or a sulfur atom, an alkenyl group having 2 to 10 carbon atoms optionally interrupted by an oxygen atom or a sulfur atom, an alkynyl group having 2 to 10 carbon atoms optionally interrupted by an oxygen atom or a sulfur atom, a benzyl group, or a phenyl group, and a phenyl group optionally substituted with at least one monovalent group selected from the group consisting of an alkyl group having 1 to 6 carbon atoms, a halogen atom, an alkoxy group having 1 to 6 carbon atoms, a nitro group, a cyano group, and an alkylthio group having 1 to 6 carbon atoms. R^1 and R^2 may be bonded to each other to form a ring having 3 to 6 carbon atoms. R^3 and R^4 may be bonded to each other to form a ring having 3 to 6 carbon atoms. * represents a bonding site. *1 represents a bonding site to a carbon atom. *2 represents a bonding site to a nitrogen atom.

[Chem. 60]



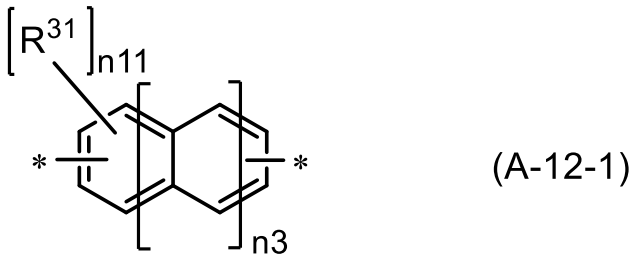
(A-11-4)

In formula (A-11-4), m1 is an integer of 1 to 4, and m2 is 0 or 1. *3 represents a bonding site to a nitrogen atom. *4 represents a bonding site to a carbon atom.

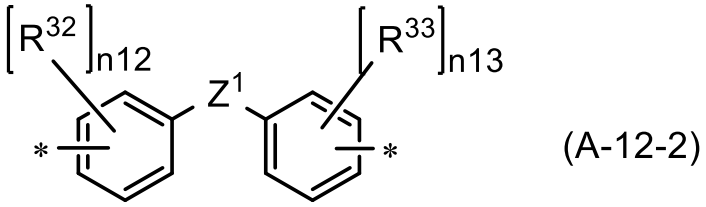
[0165]

Q^1 in formula (A-12) is preferably represented by any one of the following formulas (A-12-1) to (A-12-4).

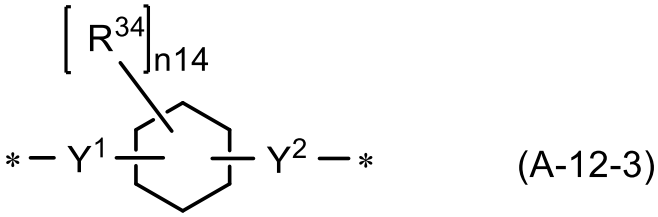
[Chem. 61]



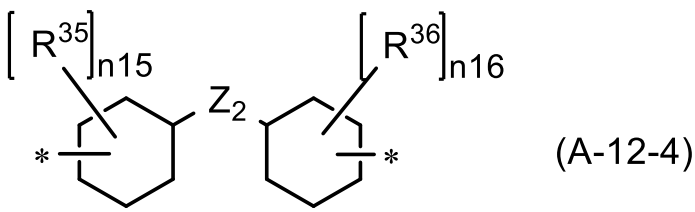
(A-12-1)



(A-12-2)



(A-12-3)



(A-12-4)

In formulas (A-12-1) to (A-12-4), R^{31} to R^{36} each independently represent a halogen atom, a hydroxy group, an alkyl group having 1 to 6 carbon atoms, an alkenyl group having 2 to 6 carbon atoms, an alkynyl group having 2 to 6 carbon atoms, an alkoxy group having 1 to 6 carbon atoms, an alkenyloxy group having 2 to 6 carbon atoms, an alkynyloxy group having 2 to 6 carbon atoms, an acyl group having 2 to 6 carbon atoms, an aryloxy group having 6 to 12 carbon atoms, an arylcarbonyl group having 7 to 13 carbon atoms, or an aralkyl group having 7 to 13 carbon atoms. * represents a bonding site.

In formula (A-12-1), n3 represents 0 or 1. When n3 is 0, n11 represents an integer of 0 to 4. When n3 is 1, n11 represents an integer of 0 to 6. When there are 2 or more R^{31}, the 2 or more R^{31} may be the same or different.

In formula (A-12-2), Z^1 represents a single bond, an oxygen atom, a sulfur atom, a carbonyl group, a sulfonyl group, or an alkylene group having 1 to 6 carbon atoms. n12 and n13 each independently represent an integer of 0 to 4. When there are 2 or more R^{32}, the 2 or more R^{32} may be the same or different. When there are 2 or more R^{33}, the 2 or more R^{33} may be the same or different.

In formula (A-12-3), Y^1 and Y^2 each independently represent a single bond or an alkylene group having 1 to 6 carbon atoms. n14 represents an integer of 0 to 4. When

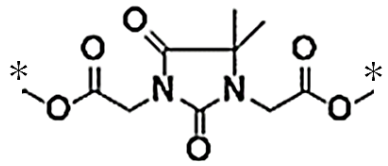
there are 2 or more R^{34}, the 2 or more R^{34} may be the same or different.

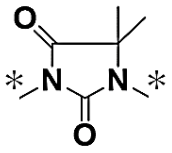
In formula (A-12-4), Z^2 represents a single bond, an oxygen atom, a sulfur atom, a carbonyl group, a sulfonyl group, or an alkylene group having 1 to 6 carbon atoms. n15 and n16 each independently represent an integer of 0 to 4. When there are 2 or more R^{35}, the 2 or more R^{35} may be the same or different. When there are 2 or more R^{36}, the 2 or more R^{36} may be the same or different.

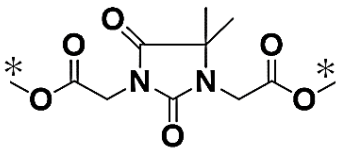
[0166]

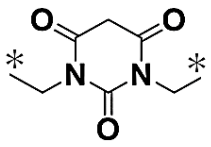
Examples of Q in formula (A-11) include the following structures.

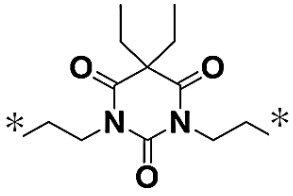
[Chem. 62]

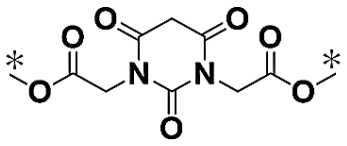


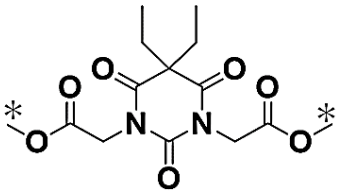




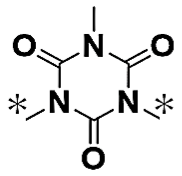
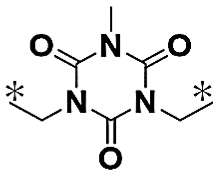
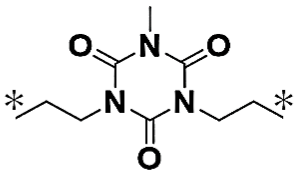
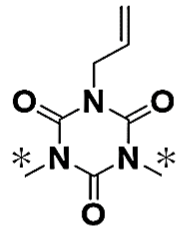
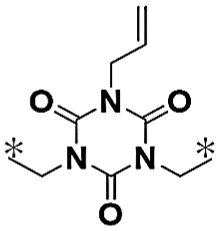
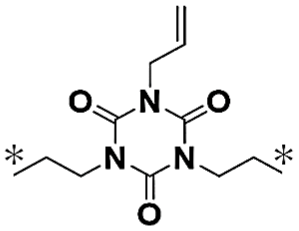
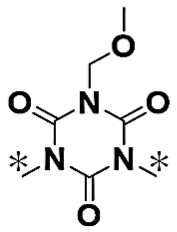
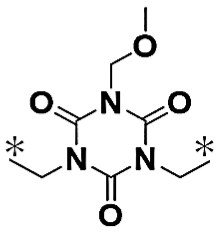
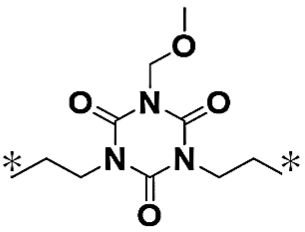




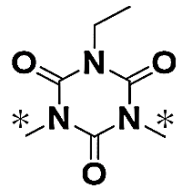
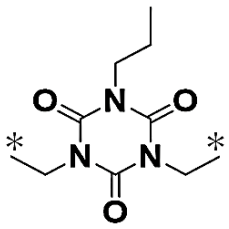
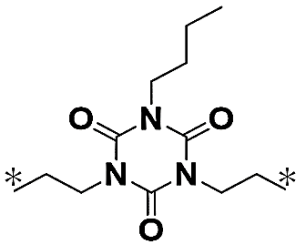
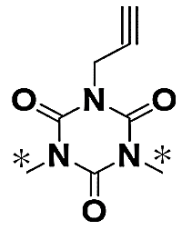
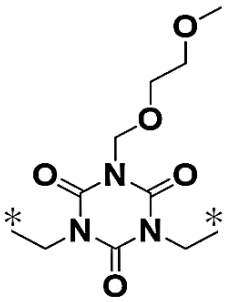
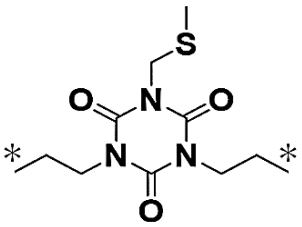




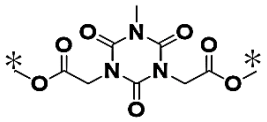
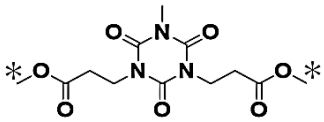
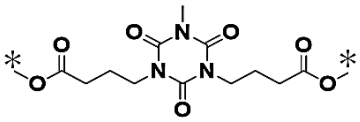
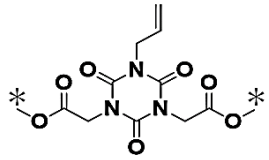
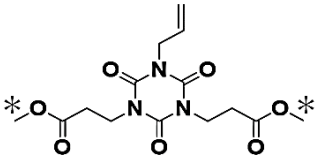
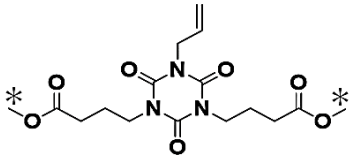
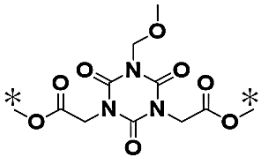
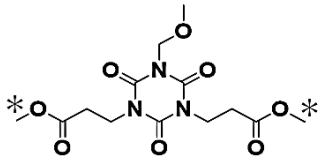
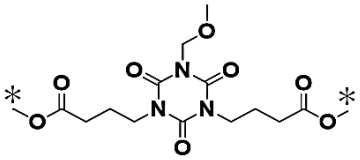
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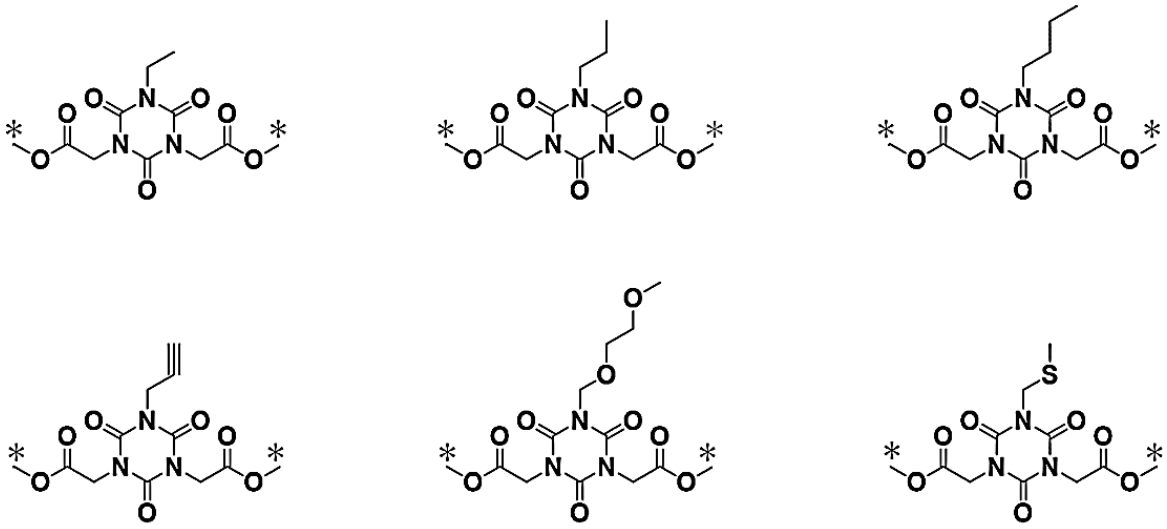
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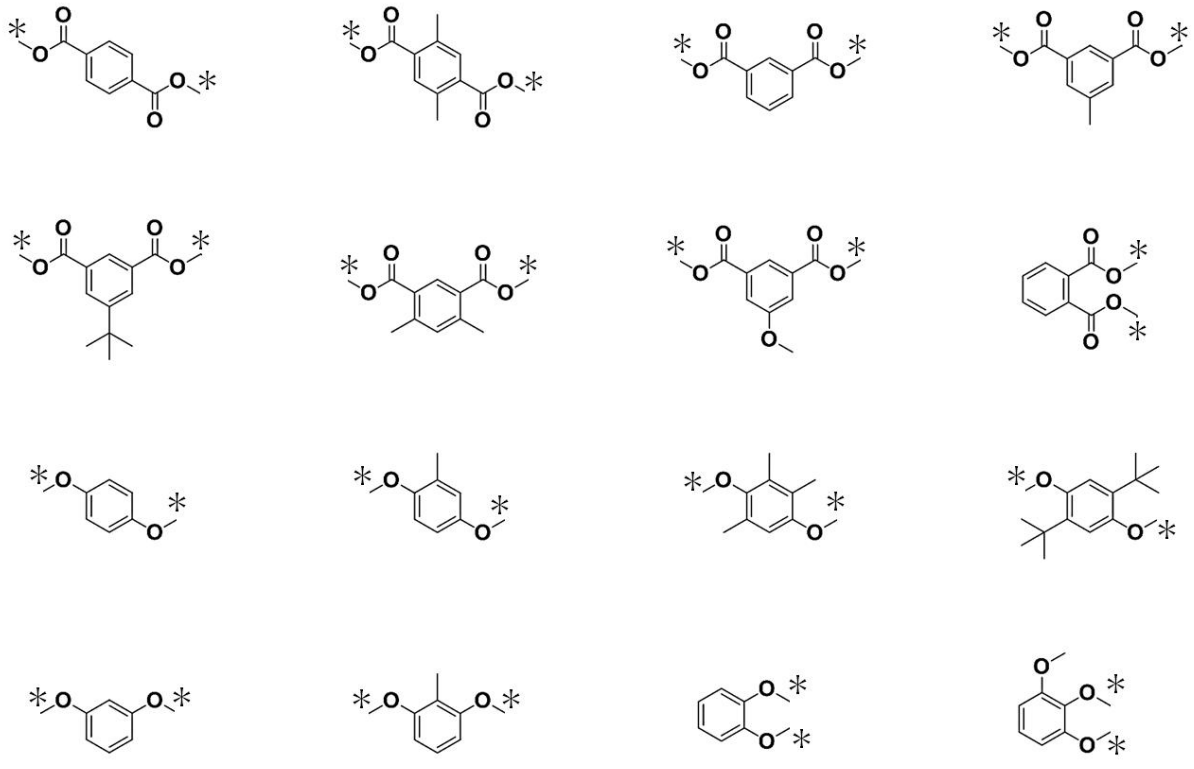
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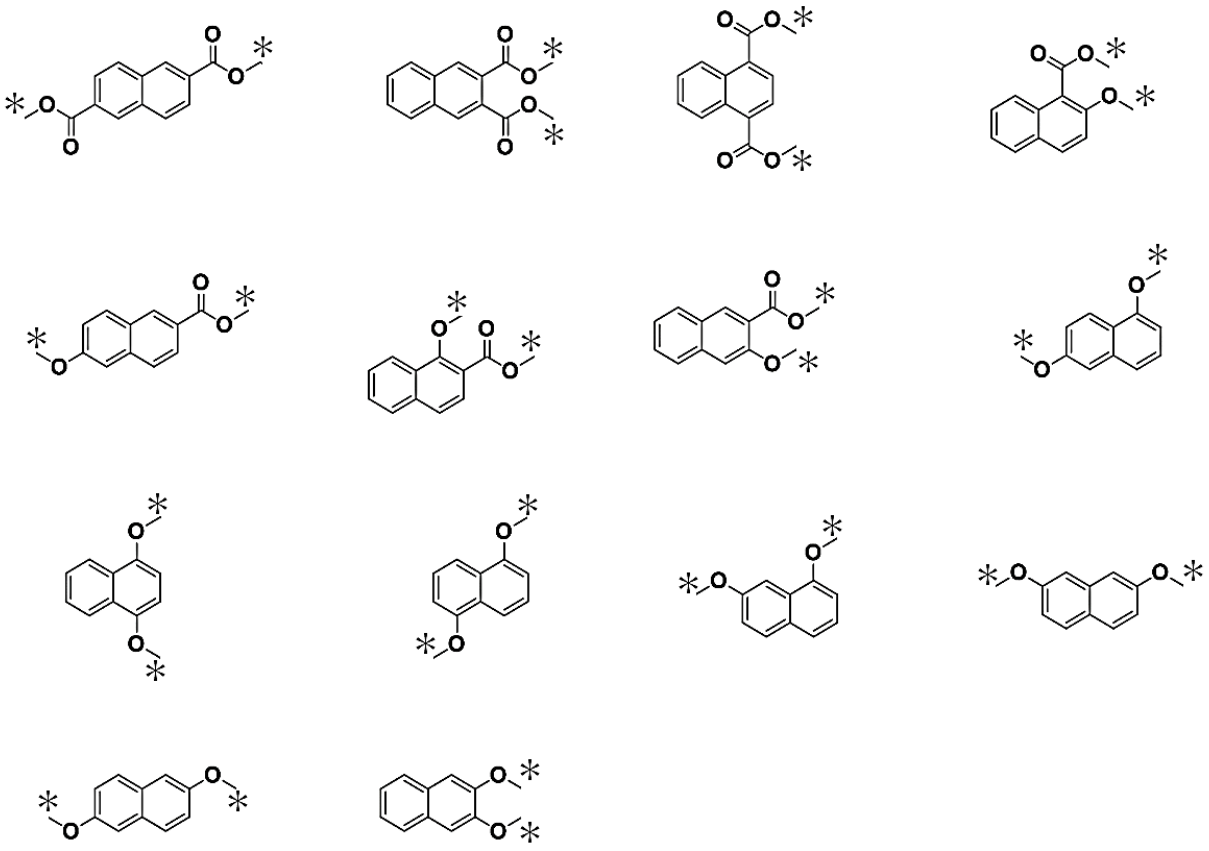
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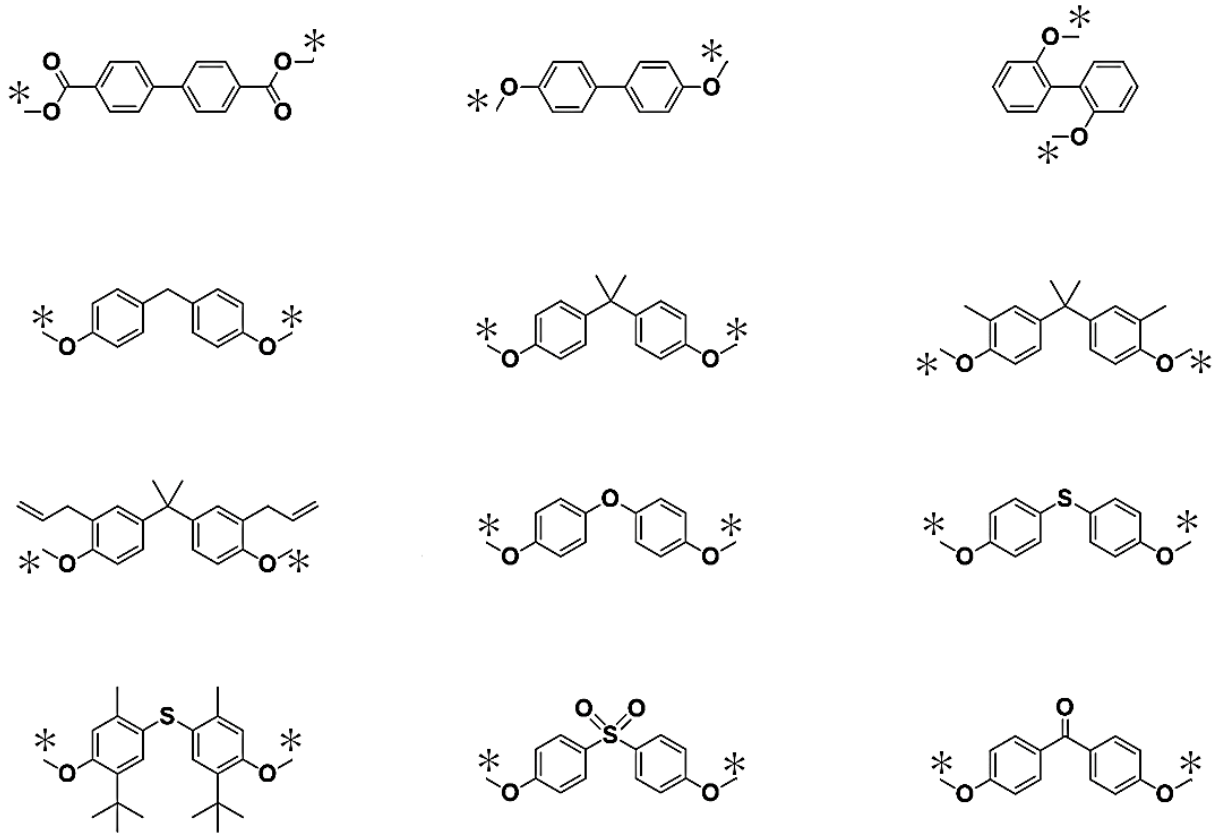
[Chem. 67]



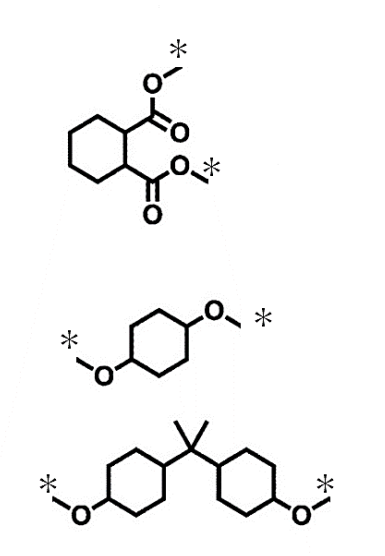
[Chem. 68]



[Chem. 69]



[Chem. 70]



* represents a bonding site.

[0167]

When the polymer (E) has a structural unit represented by formula (A-1), the mass ratio of the structural unit represented by formula (A-1) in the polymer is not particularly limited, but is preferably 50 mass% to 100 mass%, more preferably 75 mass% to 100 mass%, and particularly preferably 90 mass% to 100 mass%.

[0168]

The method for producing the polymer (E) is not particularly limited, and examples thereof include a method of reacting a dicarboxylic acid represented by the following formula (A1) with a diepoxy compound represented by the following formula (A2). In this case, a polymer having a structural unit represented by formula (A-1) is obtained.

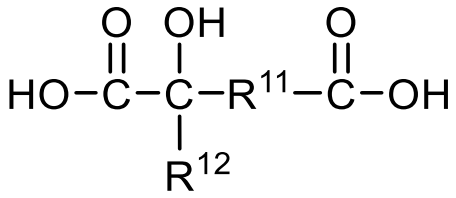
[0169]

Examples of the catalyst for activating an epoxy group include a quaternary phosphonium salt such as tetrabutylphosphonium bromide or ethyltriphenylphosphonium bromide, and a quaternary ammonium salt such as benzyltriethylammonium chloride. As the amount of the catalyst used, an appropriate amount can be selected and used from the range of 0.1 to 10 mass% based on the total mass of the polymer raw material used in the reaction. As the temperature and the time for the polymerization reaction, for example, optimum conditions can be selected

from the ranges of 80 to 160°C and 2 to 50 hours.

[0170]

[Chem. 71]



(A1)

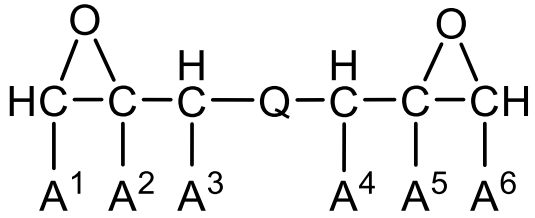
In formula (A1), R^{11} and R^{12} have the same meanings as R^{11} and R^{12} in formula (A-1), respectively.

[0171]

Examples of the dicarboxylic acid represented by formula (A1) include tartaric acid, malic acid, tartronic acid, citramalic acid, dioxymalonic acid, and mucic acid.

[0172]

[Chem. 72]



(A2)

In formula (A2), A^1, A^2, A^3, A^4, A^5, A^6 and Q have the same meanings as A^1, A^2, A^3, A^4, A^5, A^6 and Q in formula (A-1), respectively.

[0173]

The weight-average molecular weight of the polymer (E)

is not particularly limited, and is preferably 700 to 15,000, and more preferably 900 to 10,000. The weight average molecular weight is a value obtained by gel permeation chromatography (GPC) using polystyrene as a standard sample.

[0174]

The polymer (E) may be a polymer described in Japanese Patent Application No. 2024-3808 and International Application PCT/JP2025/273.

The contents of this application are incorporated herein in their entirety as if fully set forth.

[0175]

<<<Polymer (F)>>>

The polymer (F) is cellulose and a derivative thereof.

Cellulose is a polysaccharide in which D-glucose is bonded by a β-1,4 glucoside bond.

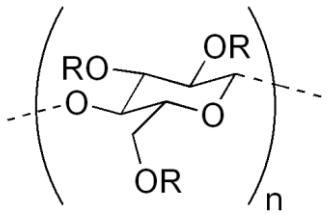
Examples of cellulose and derivatives thereof include cellulose, hydroxyethyl cellulose, hydroxypropyl cellulose, hydroxypropyl methyl cellulose, and carboxymethyl cellulose.

Among these, hydroxypropyl cellulose is preferable.

[0176]

A structural example of hydroxypropyl cellulose is shown below.

[Chem. 73]



R = H or $CH_2CH(OH)CH_3$

[0177]

<<<Polymer (G)>>>

The polymer (G) is cyclodextrin and a derivative thereof.

The cyclodextrin is a cyclic oligosaccharide in which D-glucose is bound by an α-1,4 glucoside bond to form a cyclic structure, and examples thereof include a cyclodextrin containing 6 to 12 glucose units.

Specific examples of the cyclodextrin include α-cyclodextrin in which six D-glucose are cyclized, β-cyclodextrin in which seven D-glucose are cyclized, γ-cyclodextrin in which eight D-glucose are cyclized, derivatives of these cyclodextrins, and polymers partially having a cyclodextrin structure.

[0178]

The derivative of cyclodextrin is a compound in which some or all of the hydroxy groups at the 2, 3, and 6 positions of glucose in the cyclodextrin are substituted with other functional groups, and examples thereof include an alkyl derivative, a hydroxyalkyl derivative, an alkoxy

derivative, a sulfoalkyl ether derivative, and a sugar bond derivative.

Specific examples of the cyclodextrin derivative include hydroxymethylcyclodextrin, hydroxyethylcyclodextrin, hydroxypropylcyclodextrin, hydroxybutylcyclodextrin, dimethylcyclodextrin, trimethylcyclodextrin, diethylcyclodextrin, triethylcyclodextrin, carboxymethylcyclodextrin, glucosylcyclodextrin, maltosylcyclodextrin, dimaltosylcyclodextrin, monochlorotriazinylcyclodextrin, and cyclodextrin-epichlorohydrin polymers.

[0179]

More specific examples of the compound include a sugar bond derivative, an alkylated cyclodextrin, a hydroxyalkylated cyclodextrin, a sulfoalkyl ether derivative, and an alkoxylated cyclodextrin.

Examples of the sugar bond derivative include glucosyl-α-cyclodextrin, glucosyl-β-cyclodextrin, and glucosyl-γ-cyclodextrin.

Examples of the alkylated cyclodextrin include 2,6-di-O-methyl-α-cyclodextrin, 2,3,6-tri-O-methyl-α-cyclodextrin, 2,6-di-O-methyl-β-cyclodextrin, 2,3,6-tri-O-methyl-β-cyclodextrin, 2,6-di-O-methyl-γ-cyclodextrin, and 2,3,6-tri-O-methyl-γ-cyclodextrin.

Examples of the hydroxyalkylated cyclodextrin include

2-hydroxyethyl-α-cyclodextrin, 2-hydroxypropyl-α-cyclodextrin, 3-hydroxypropyl-α-cyclodextrin, 2,3-dihydroxypropyl-α-cyclodextrin, 2-hydroxyethyl-β-cyclodextrin, 2-hydroxypropyl-β-cyclodextrin, 2,3-dihydroxypropyl-β-cyclodextrin, 2-hydroxyethyl-γ-cyclodextrin, 2-hydroxypropyl-γ-cyclodextrin, 3-hydroxypropyl-γ-cyclodextrin, and 2,3-dihydroxypropyl-γ-cyclodextrin.

Examples of the carboxyalkylated cyclodextrin include O-carboxymethyl-α-cyclodextrin, O-carboxymethyl-β-cyclodextrin, and O-carboxymethyl-γ-cyclodextrin.

Examples of the sulfoalkyl ether derivative include sulfobutyl ether-α-cyclodextrin, sulfobutyl ether-β-cyclodextrin, and sulfobutyl ether-γ-cyclodextrin.

Examples of the alkoxylated cyclodextrin include methoxycyclodextrin and ethoxycyclodextrin.

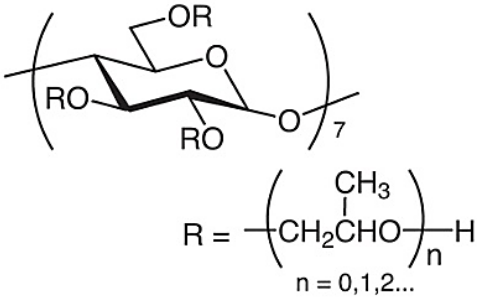
[0180]

Among these, hydroxyalkylated cyclodextrin is preferable, and 2-hydroxypropyl-β-cyclodextrin is more preferable.

[0181]

Structural examples of 2-hydroxypropyl-β-cyclodextrin are shown below.

[Chem. 74]



[0182]

<<<Polymer (H)>>>

The polymer (H) is a polymer having a structural unit derived from hydroxyalkyl (meth)acrylate.

Examples of the polymer having a structural unit derived from hydroxyalkyl (meth)acrylate include a homopolymer of hydroxyalkyl (meth)acrylate and a copolymer of hydroxyalkyl (meth)acrylate and another monomer.

[0183]

The number of carbon atoms of the hydroxyalkyl group in the hydroxyalkyl (meth)acrylate is, for example, 1 to 6.

Examples of the hydroxyalkyl (meth)acrylate include 2-hydroxyethyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, and 6-hydroxyhexyl (meth)acrylate.

The (meth)acrylate refers to acrylate and/or methacrylate.

[0184]

The other monomer used for copolymerization is not particularly limited, and examples thereof include (meth)acrylic acid, a (meth)acrylic acid ester compound, a (meth)acrylamide compound, a vinyl compound, a styrene compound, and acrylonitrile.

[0185]

Specific examples of the (meth)acrylic acid ester compound include methyl (meth)acrylate, ethyl (meth)acrylate, n-hexyl (meth)acrylate, i-propyl (meth)acrylate, cyclohexyl (meth)acrylate, benzyl (meth)acrylate, phenyl (meth)acrylate, anthrylmethyl (meth)acrylate, 2-methoxyethyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, 2-methyl-2-adamantyl (meth)acrylate, and glycidyl (meth)acrylate.

[0186]

Specific examples of the (meth)acrylamide compound include (meth)acrylamide, N-methyl (meth)acrylamide, N-ethyl (meth)acrylamide, N-benzyl (meth)acrylamide, N-phenyl (meth)acrylamide, N,N-dimethyl (meth)acrylamide, and N-anthryl (meth)acrylamide.

[0187]

Specific examples of the vinyl compound include vinyl alcohol, 2-hydroxyethyl vinyl ether, methyl vinyl ether, ethyl vinyl ether, benzyl vinyl ether, vinylacetic acid, vinyltrimethoxysilane, 2-chloroethyl vinyl ether, 2-

methoxyethyl vinyl ether, vinylnaphthalene, and vinylanthracene.

[0188]

Specific examples of the styrene compound include styrene, hydroxystyrene, chlorostyrene, bromostyrene, methoxystyrene, cyanostyrene, and acetylstyrene.

[0189]

The constituent ratio of other monomers in the case of a copolymer is not particularly limited.

[0190]

Among these, a homopolymer of 2-hydroxyethyl acrylate is preferable.

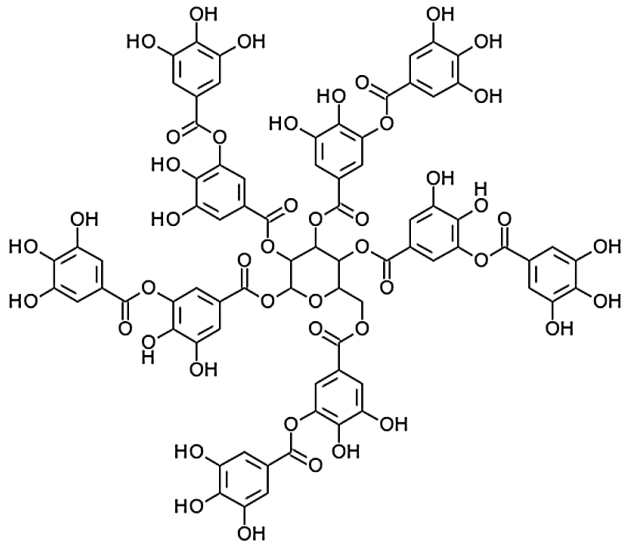
[0191]

<<<Compound (A)>>>

The compound (A) is tannic acid.

Tannic acid is represented by the following structure.

[Chem. 75]



[0192]

<<<Polymer (I)>>>

The polymer (I) is a polymer having a lactam structure.

Examples of the polymer having a lactam structure include a polymer having a γ-lactam that is a 5-membered lactam in a side chain and a polymer having a δ-lactam that is a 6-membered lactam in a side chain.

Examples of the lactam structure include a pyrrolidone ring and an alkylated pyrrolidone ring in which at least a part of hydrogen atoms of the pyrrolidone ring is substituted with an alkyl group. Examples of the alkyl group include an alkyl group having 1 to 6 carbon atoms.

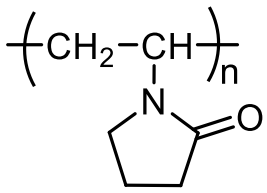
[0193]

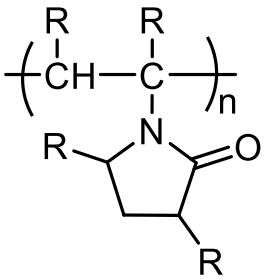
Examples of the polymer having a lactam structure include polyvinylpyrrolidone, alkylated polyvinylpyrrolidone, and vinylpyrrolidone-vinyl acetate copolymer.

[0194]

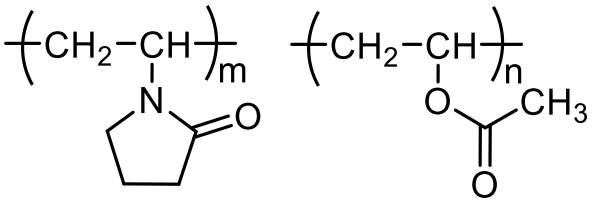
Structural examples of polyvinylpyrrolidone, alkylated polyvinylpyrrolidone, and vinylpyrrolidone-vinyl acetate copolymer are shown below.

[Chem. 76]





R: H or alkyl group



[0195]

The polymer having a lactam structure may be a commercially available product. Examples of commercially available products of polyvinylpyrrolidone include K-30 and K-90 (Nippon Shokubai Co., Ltd.). Examples of a commercially available product of the alkylated polyvinylpyrrolidone include Ganex P-904 LC (Ashland Inc.). Examples of a commercially available product of the vinylpyrrolidone-vinyl acetate copolymer include PVP/VA S-630 (Ashland Inc.).

[0196]

The weight-average molecular weight of the compound or polymer is not particularly limited, but is preferably 700

to 5,000,000, and more preferably 900 to 100,000. The weight average molecular weight is a value obtained by gel permeation chromatography (GPC) using polystyrene as a standard sample.

[0197]

The content of the "compound or polymer" in the composition for forming a coating film for removing foreign matters is not particularly limited, but is preferably 70 mass% to 99.9 mass%, more preferably 80 mass% to 99.5 mass%, and particularly preferably 90 mass% to 99 mass% based on the film-forming component.

[0198]

<<Removing liquid>>

The removing liquid is not particularly limited as long as it can remove the coating film formed from the composition for forming a coating film for removing foreign matters.

The coating film is formed on, for example, a semiconductor substrate. In this case, the removal refers to removal from the semiconductor substrate.

Herein, examples of the mode of removal include dissolution removal and peeling removal. Examples of the peeling removal include peeling from an adherend by swelling.

[0199]

The removing liquid may contain water or an organic solvent.

The removing liquid may be a removing liquid that contains an organic solvent in an amount of 50 mass% or more.

[0200]

The removing liquid may be water. The water is not particularly limited as long as it is water typically used in semiconductor production, and examples thereof include pure water, ultrapure water, and ion exchange water.

[0201]

Examples of the organic solvent include ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, methyl cellosolve acetate, ethyl cellosolve acetate, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, propylene glycol, propylene glycol monomethyl ether, propylene glycol monomethyl ether acetate, propylene glycol propyl ether acetate, toluene, xylene, methyl ethyl ketone, cyclopentanone, cyclohexanone, ethyl 2-hydroxypropionate, ethyl 2-hydroxy-2-methylpropionate, ethyl ethoxyacetate, ethyl hydroxyacetate, methyl 2-hydroxy-3-methylbutanoate, methyl 3-methoxypropionate, ethyl 3-methoxypropionate, ethyl 3-ethoxypropionate, methyl 3-ethoxypropionate, methyl pyruvate, ethyl pyruvate, ethyl acetate, butyl acetate, ethyl lactate, butyl lactate, N,N-dimethylformamide, N,N-

dimethylacetamide, and N-methylpyrrolidone.

[0202]

Examples of the removing liquid include an alkaline removing liquid and an acidic removing liquid.

[0203]

The alkaline removing liquid contains an alkali. Examples of the alkali include ammonia, an inorganic alkaline compound, quaternary ammonium hydroxide, an amine, and hydrazine.

The alkaline removing liquid may be a developer or a cleaning liquid used in a semiconductor production process, and may exhibit alkalinity. Examples of the developer include NMD-3 (2.38% tetramethylammonium hydroxide aqueous solution, manufactured by TOKYO OHKA KOGYO CO., LTD.).

Examples of the inorganic alkaline compound include potassium hydroxide, sodium hydroxide, lithium hydroxide, diammonium hydrogen phosphate, dipotassium hydrogen phosphate, disodium hydrogen phosphate, lithium silicate, sodium silicate, potassium silicate, lithium carbonate, sodium carbonate, potassium carbonate, lithium borate, sodium borate, and potassium borate.

Examples of the quaternary ammonium hydroxide include tetramethylammonium hydroxide, tetraethylammonium hydroxide, trimethylhydroxyethylammonium hydroxide, and choline.

Examples of the amine include ethanolamine, methylamine, dimethylamine, trimethylamine, monoethylamine, diethylamine, triethylamine, n-propylamine, di-n-propylamine, isopropylamine, diisopropylamine, methyldiethylamine, dimethylethanolamine, triethanolamine, and ethylenediamine.

Examples of the hydrazine include hydrazine monohydrate.

The alkaline removing liquid may be SC-1 (ammonia-hydrogen peroxide solution).

[0204]

The acidic removing liquid contains an acid. Examples of the acid include an inorganic acid and an organic acid. Examples of the inorganic acid include sulfuric acid, nitric acid, hydrochloric acid, phosphoric acid, and hydrofluoric acid.

The acidic removing liquid is, for example, an aqueous solution containing dilute hydrofluoric acid.

The acidic removing liquid may be, for example, an aqueous solution containing sulfuric acid and hydrogen peroxide, or an aqueous solution containing acetic acid or a chelating agent. Examples of the chelating agent include organic acids, salts of organic acids, amino acids, and derivatives of amino acids.

[0205]

<Solvent>

Examples of the solvent contained in the composition for forming a coating film for removing foreign matters include ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, methyl cellosolve acetate, ethyl cellosolve acetate, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, propylene glycol, propylene glycol monomethyl ether, propylene glycol monomethyl ether acetate, propylene glycol propyl ether acetate, toluene, xylene, methyl ethyl ketone, cyclopentanone, cyclohexanone, ethyl 2-hydroxypropionate, ethyl 2-hydroxy-2-methylpropionate, ethyl ethoxyacetate, ethyl hydroxyacetate, methyl 2-hydroxy-3-methylbutanoate, methyl 3-methoxypropionate, ethyl 3-methoxypropionate, ethyl 3-ethoxypropionate, methyl 3-ethoxypropionate, methyl pyruvate, ethyl pyruvate, ethyl acetate, butyl acetate, ethyl lactate, butyl lactate, N,N-dimethylformamide, N,N-dimethylacetamide, and N-methylpyrrolidone.

These solvents may be used singly or in combination of two or more types thereof.

Further, a high-boiling-point solvent such as propylene glycol monobutyl ether or propylene glycol monobutyl ether acetate can be mixed and used.

[0206]

The composition for forming a coating film for removing

foreign matters can be easily prepared, for example, by uniformly mixing the respective components, and is dissolved in an appropriate solvent and used in a solution state.

Preferably, the composition for forming a coating film for removing foreign matters thus prepared is filtered using a filter having a pore size of about 0.2 μm or the like and then used. The composition for forming a coating film for removing foreign matters thus prepared is also excellent in long-term storage stability at room temperature.

[0207]

The ratio of the solid content in the composition for forming a coating film for removing foreign matters is not particularly limited as long as the components are uniformly dissolved. The ratio is, for example, 0.5 to 50 mass%, or, for example, 1 to 30 mass%. Herein, the solid content means components left after removal of the solvent component from all the components of the composition for forming a coating film for removing foreign matters.

[0208]

In the present invention, the foreign matters mean materials that are deposited on the substrate but are other than the intended material. In the semiconductor device production, the foreign matters are unnecessary materials.

Examples of the foreign matters include particles deposited on the wafer, metal impurities, etching residues, and peeling residues of the adhesive layer.

[0209]

The coating film for removing foreign matters is particularly preferably used, in the step of bonding wafers using an adhesive, and then peeling off the adhesive, by forming the coating film of the present invention before applying the adhesive, and conducting wafer bonding and peeling steps, and then peeling off foreign matters (residue of the adhesive layer).

[0210]

The coating film for removing foreign matters can also be used to remove pre-existing foreign matters on a semiconductor substrate.

[0211]

The "coating film for removing foreign matters is soluble in a removing liquid" means that when the coating film is immersed in the removing liquid, cleaned with the removing liquid, or the like, the coating film is dissolved in the removing liquid, and it is not present on an adherend such as a substrate. The term "dissolved (or dissolution)" in the present invention means that at least 90% or more of the thickness of the film originally formed is removed (i.e. the thickness of the residual film is 10%

or less that of the original film); or at least 95% or more of the thickness of the original film is removed (i.e. the thickness of the residual film is 5% or less that of the original film); or at least 99% or more of the thickness of the original film is removed (i.e. the thickness of the residual film is 1% or less that of the original film), and most preferably 100% of the thickness of the original film is removed (i.e. the thickness of the residual film is 0% of the thickness of the original film (no residual film remains)), from the film formed on the substrate.

[0212]

Preferably, the composition contains at least one of a crosslinking agent and an additive.

[0213]

<<Crosslinking agent>>

The film-forming component may contain, for example, a crosslinking agent.

The crosslinking agent is not particularly limited.

The crosslinking agent has a structure different from the coordinating compound, and “compound or polymer”.

[0214]

As the crosslinking agent, an aminoplast crosslinking agent and a phenoplast crosslinking agent are preferable.

The aminoplast crosslinking agent is an addition condensate of a compound having an amino group, such as

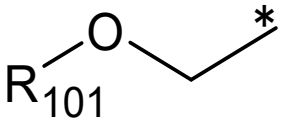
melamine or guanamine, and formaldehyde.

The phenoplast crosslinking agent is an addition condensate of a compound having a phenolic hydroxy group and formaldehyde.

[0215]

Examples of the crosslinking agent include a compound having two or more structures shown below.

[Chem. 77]



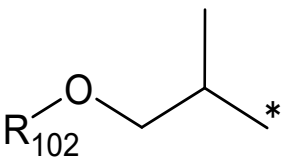
In the structure, R_{101} represents a hydrogen atom, an alkyl group having 1 to 4 carbon atoms, or an alkoxyalkyl group having 2 to 6 carbon atoms. * represents a bonding site.

The bonding site is bonded to, for example, a nitrogen atom, a carbon atom constituting an aromatic hydrocarbon ring, or the like.

[0216]

As R_{101}, a hydrogen atom, a methyl group, an ethyl group, or a group represented by the following structure is preferable.

[Chem. 78]



In the structure, R_{102} represents a hydrogen atom, a methyl group, or an ethyl group. * represents a bonding site.

[0217]

The crosslinking agent is preferably a melamine compound, a guanamine compound, a glycoluril compound, a urea compound, or a compound having a phenolic hydroxy group. These compounds can be used singly or in combination of two or more.

[0218]

Examples of the melamine compound include hexamethylolmelamine, hexamethoxymethylmelamine, a compound in which 1 to 6 methylol groups of hexamethylolmelamine are methoxymethylated or a mixture thereof, hexamethoxyethylmelamine, hexaacyloxymethylmelamine, and a compound in which 1 to 6 methylol groups of hexamethylolmelamine are acyloxymethylated or a mixture thereof.

[0219]

Examples of the guanamine compound include tetramethylolguanamine, tetramethoxymethylguanamine, a compound in which 1 to 4 methylol groups of tetramethylolguanamine are methoxymethylated or a mixture thereof, tetramethoxyethylguanamine, tetraacyloxyguanamine, and a compound in which 1 to 4 methylol groups of

tetramethylolguanamine are acyloxymethylated or a mixture thereof.

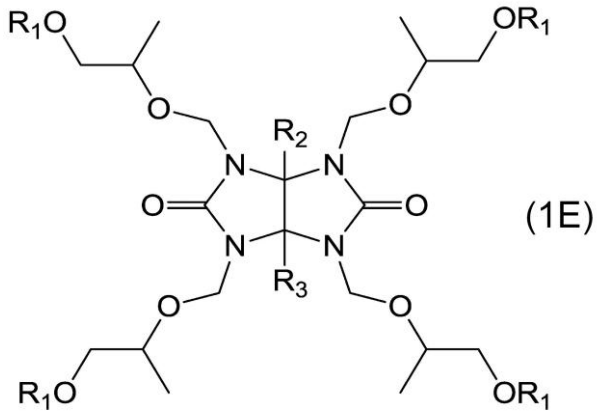
[0220]

Examples of the glycoluril compound include tetramethylolglycoluril, tetramethoxyglycoluril, tetramethoxymethylglycoluril, a compound in which 1 to 4 methylol groups of tetramethylolglycoluril are methoxymethylated or a mixture thereof, and a compound in which 1 to 4 methylol groups of tetramethylolglycoluril are acyloxymethylated or a mixture thereof.

[0221]

The glycoluril compound may be, for example, a glycoluril derivative represented by formula (1E) below.

[Chem. 79]

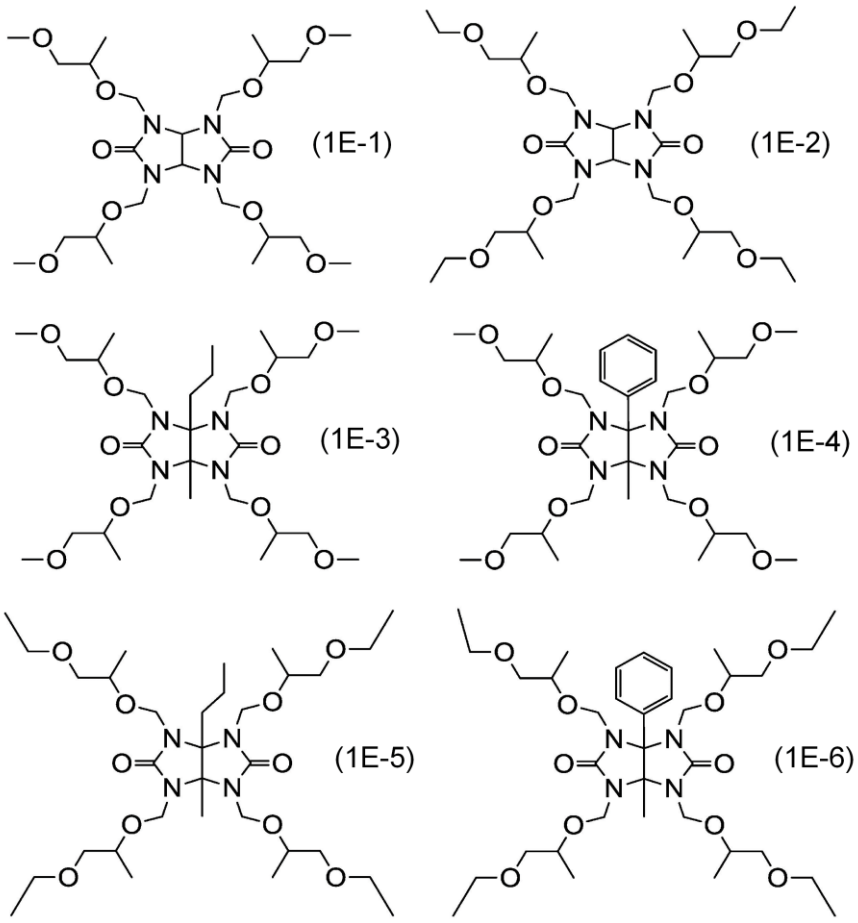


In the formula (1E), four R_1 each independently represent a methyl group or an ethyl group, and R_2 and R_3 each independently represent a hydrogen atom, an alkyl group having 1 to 4 carbon atoms, or a phenyl group.

[0222]

Examples of the glycoluril derivative represented by formula (1E) include compounds represented by formulas (1E-1) to (1E-6) below.

[Chem. 80]

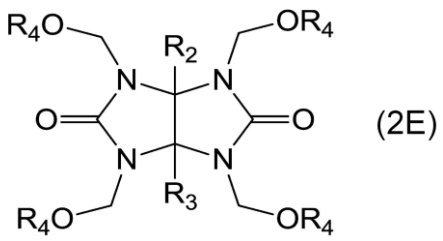


[0223]

The glycoluril derivative represented by formula (1E) is obtained by, for example, reacting a glycoluril derivative represented by formula (2E) below with at least one type of compound represented by formula (3d) below.

[0224]

[Chem. 81]

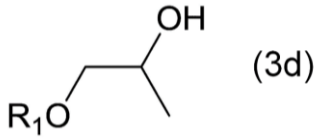


(2E)

In formula (2E), R_2 and R_3 each independently represent a hydrogen atom, an alkyl group having 1 to 4 carbon atoms, or a phenyl group, and R_4 each independently represents an alkyl group having 1 to 4 carbon atoms.

[0225]

[Chem. 82]



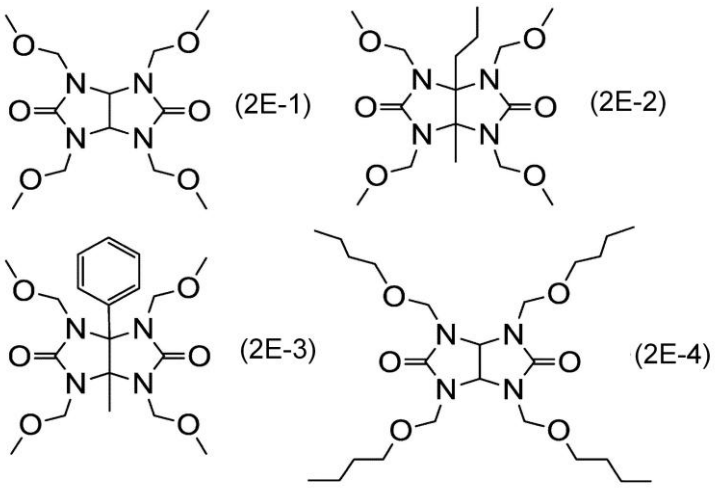
(3d)

In formula (3d), R_1 represents a methyl group or an ethyl group.

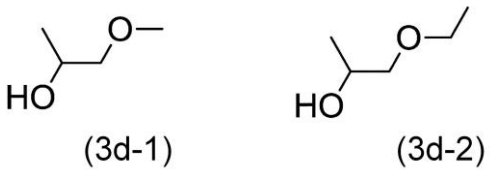
[0226]

Examples of the glycoluril derivative represented by formula (2E) include compounds represented by formulas (2E-1) to (2E-4) below. Further, examples of the compound represented by formula (3d) include compounds represented by formulas (3d-1) and (3d-2) below.

[Chem. 83]



[Chem. 84]



(3d-1) (3d-2)

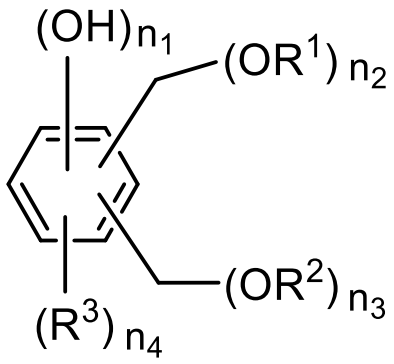
[0227]

Examples of the urea compound include tetramethylolurea, tetramethoxymethylurea, a compound in which 1 to 4 methylol groups of tetramethylolurea are methoxymethylated or a mixture thereof, and tetramethoxyethylurea.

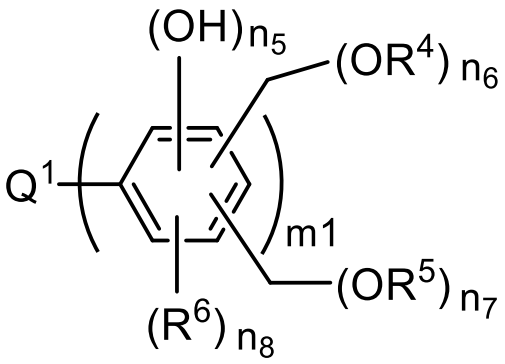
[0228]

Examples of the compound having a phenolic hydroxy group include a compound represented by formula (G-1) or formula (G-2) below.

[Chem. 85]



(G-1)



(G-2)

In formulas (G-1) and (G-2), Q^1 represents a single bond or an m1-valent organic group.

R^1 and R^4 each represent an alkyl group having 2 to 10 carbon atoms or an alkyl group having 2 to 10 carbon atoms and having an alkoxy group having 1 to 10 carbon atoms.

R^2 and R^5 each represent a hydrogen atom or a methyl group.

R^3 and R^6 each represent an alkyl group having 1 to 10 carbon atoms or an aryl group having 6 to 40 carbon atoms.

n_1 represents an integer satisfying $1 \leq n_1 \leq 3$, n_2 represents an integer satisfying $2 \leq n_2 \leq 5$, n_3 represents an integer satisfying $0 \leq n_3 \leq 3$, n_4 represents an integer satisfying $0 \leq n_4 \leq 3$, and $3 \leq (n_1 + n_2 + n_3 + n_4) \leq 6$.

n_5 represents an integer satisfying $1 \leq n_5 \leq 3$, n_6 represents an integer satisfying $1 \leq n_6 \leq 4$, n_7 represents an integer satisfying $0 \leq n_7 \leq 3$, n_8 represents an integer satisfying $0 \leq n_8 \leq 3$, and $2 \leq (n_5 + n_6 + n_7 + n_8) \leq 5$.

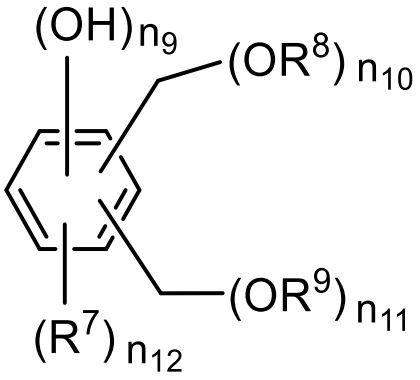
m1 represents an integer from 2 to 10.

[0229]

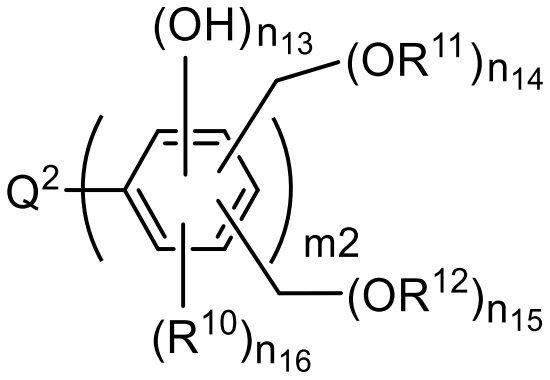
Examples of the compound having a phenolic hydroxy group include a compound represented by formula (G-3) or formula (G-4) below.

The compound represented by formula (G-1) or formula (G-2) may be obtained by a reaction of a compound represented by formula (G-3) or formula (G-4) below with a hydroxyl group-containing ether compound or an alcohol having 2 to 10 carbon atoms.

[Chem. 86]



(G-3)



(G-4)

In formulas (G-3) and (G-4), Q^2 represents a single bond or an m2-valent organic group.

R^8, R^9, R^{11}, and R^{12} each represent a hydrogen atom or a methyl group.

R^7 and R^{10} each represent an alkyl group having 1 to 10 carbon atoms or an aryl group having 6 to 40 carbon atoms.

n_9 represents an integer satisfying $1 \leq n_9 \leq 3$, n_{10} represents an integer satisfying $2 \leq n_{10} \leq 5$, n_{11} represents

an integer satisfying $0 \leq n_{11} \leq 3$, n_{12} represents an integer satisfying $0 \leq n_{12} \leq 3$, and $3 \leq (n_9 + n_{10} + n_{11} + n_{12}) \leq 6$.

n_{13} represents an integer satisfying $1 \leq n_{13} \leq 3$, n_{14} represents an integer satisfying $1 \leq n_{14} \leq 4$, n_{15} represents an integer satisfying $0 \leq n_{15} \leq 3$, and n_{16} represents an integer satisfying $0 \leq n_{16} \leq 3$, and $2 \leq (n_{13} + n_{14} + n_{15} + n_{16}) \leq 5$.

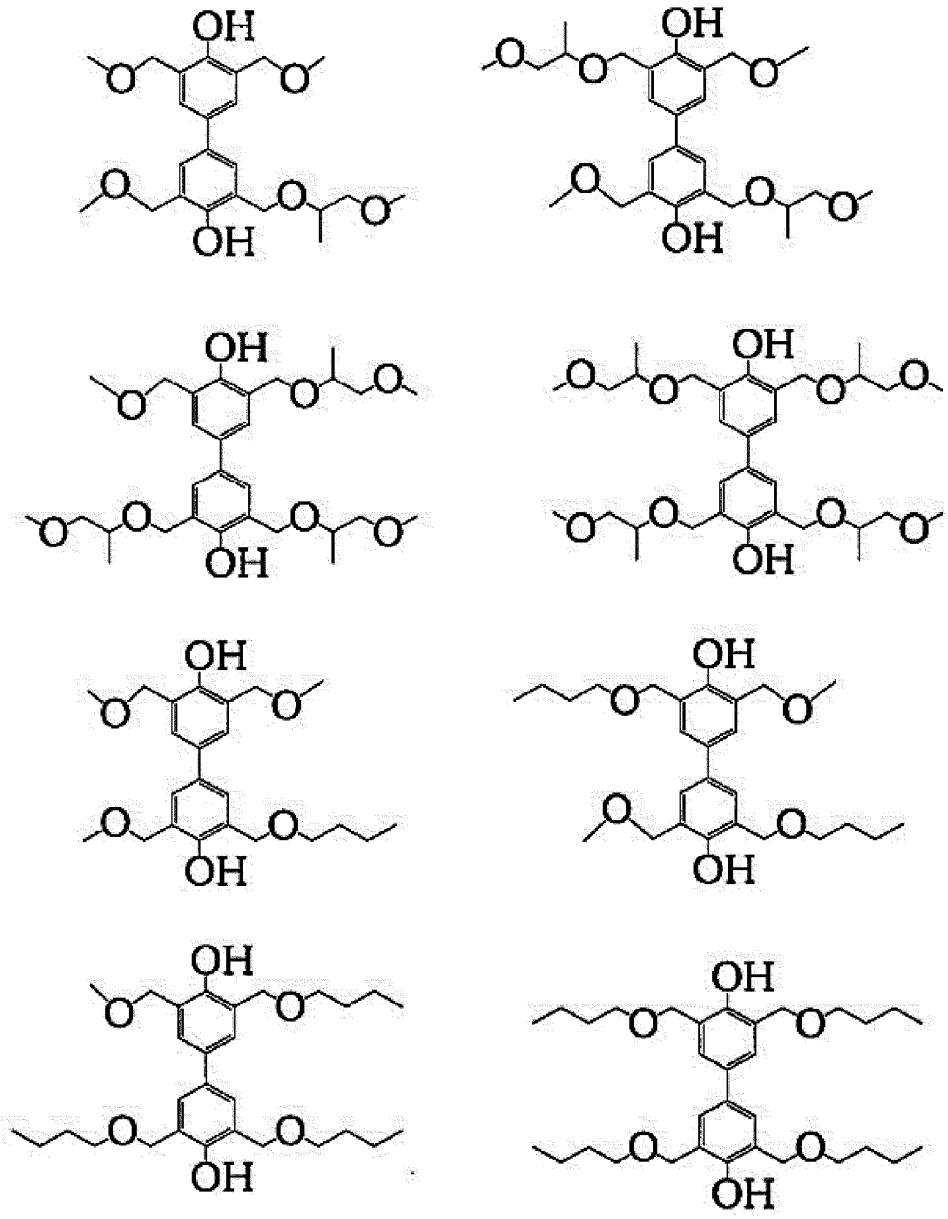
m2 represents an integer from 2 to 10.

Examples of the m2-valent organic group of Q^2 include an m2-valent organic group having 1 to 4 carbon atoms.

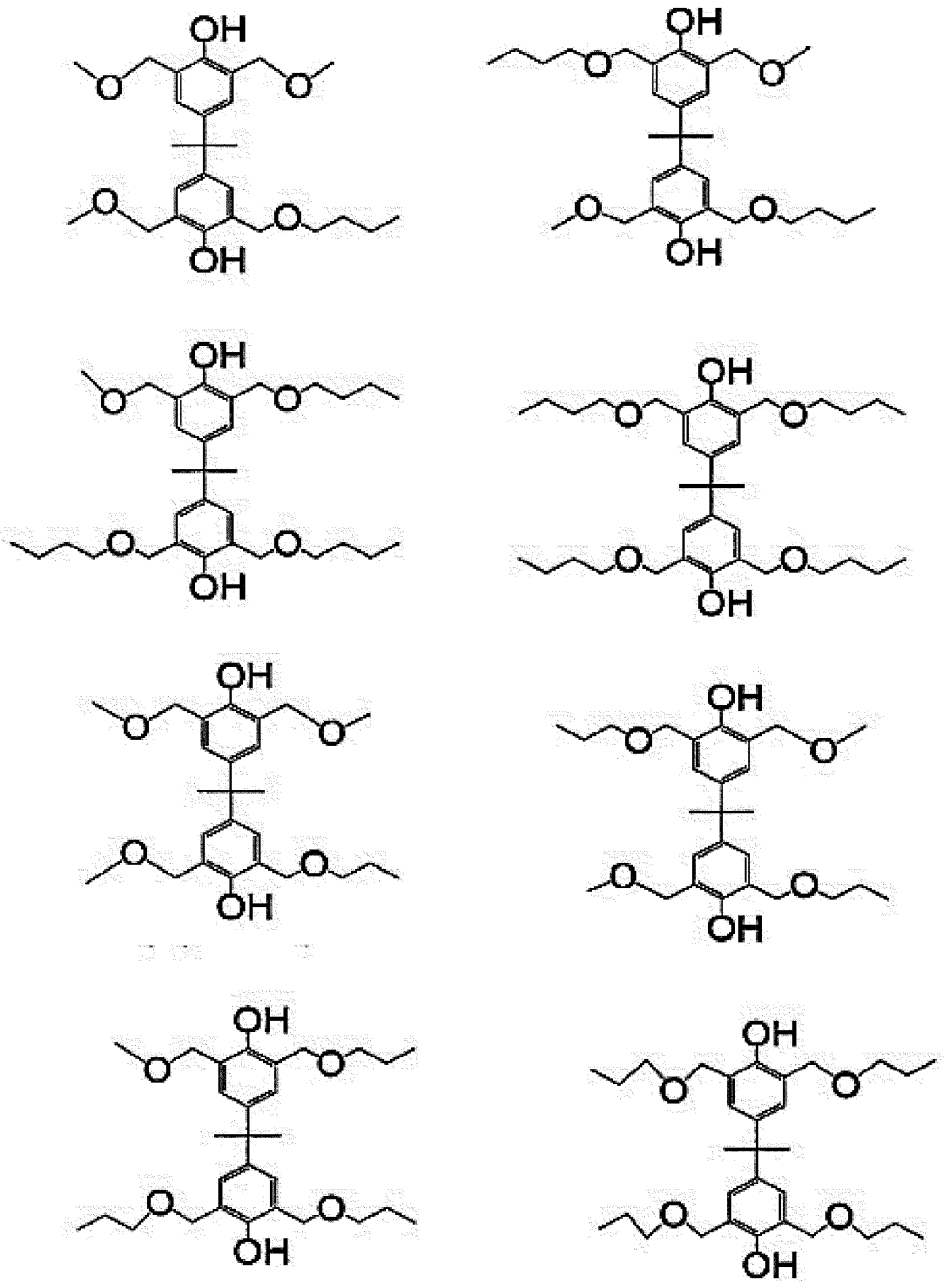
[0230]

Examples of the compound represented by formula (G-1) or formula (G-2) include the following compounds.

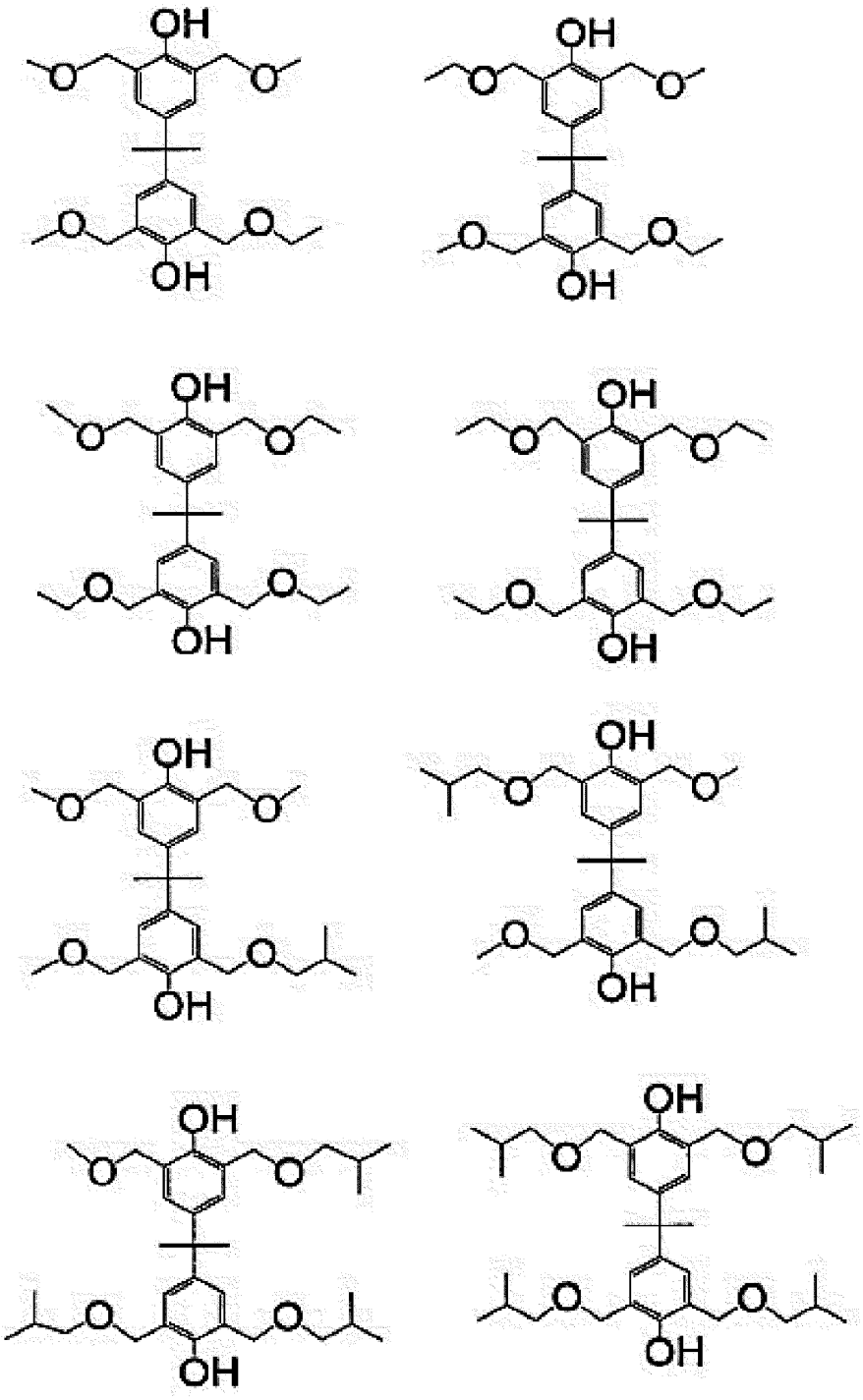
[Chem. 87]



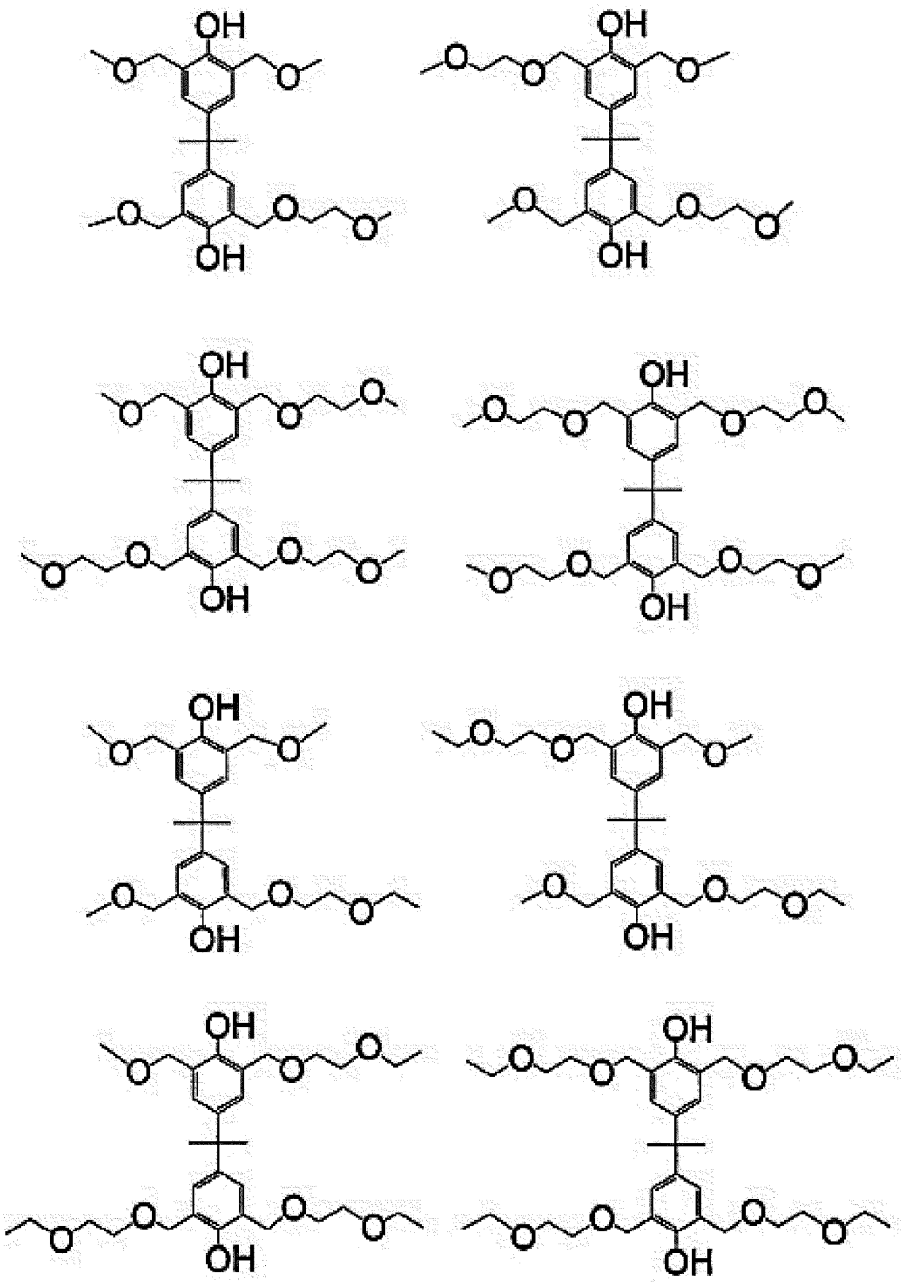
[Chem. 88]



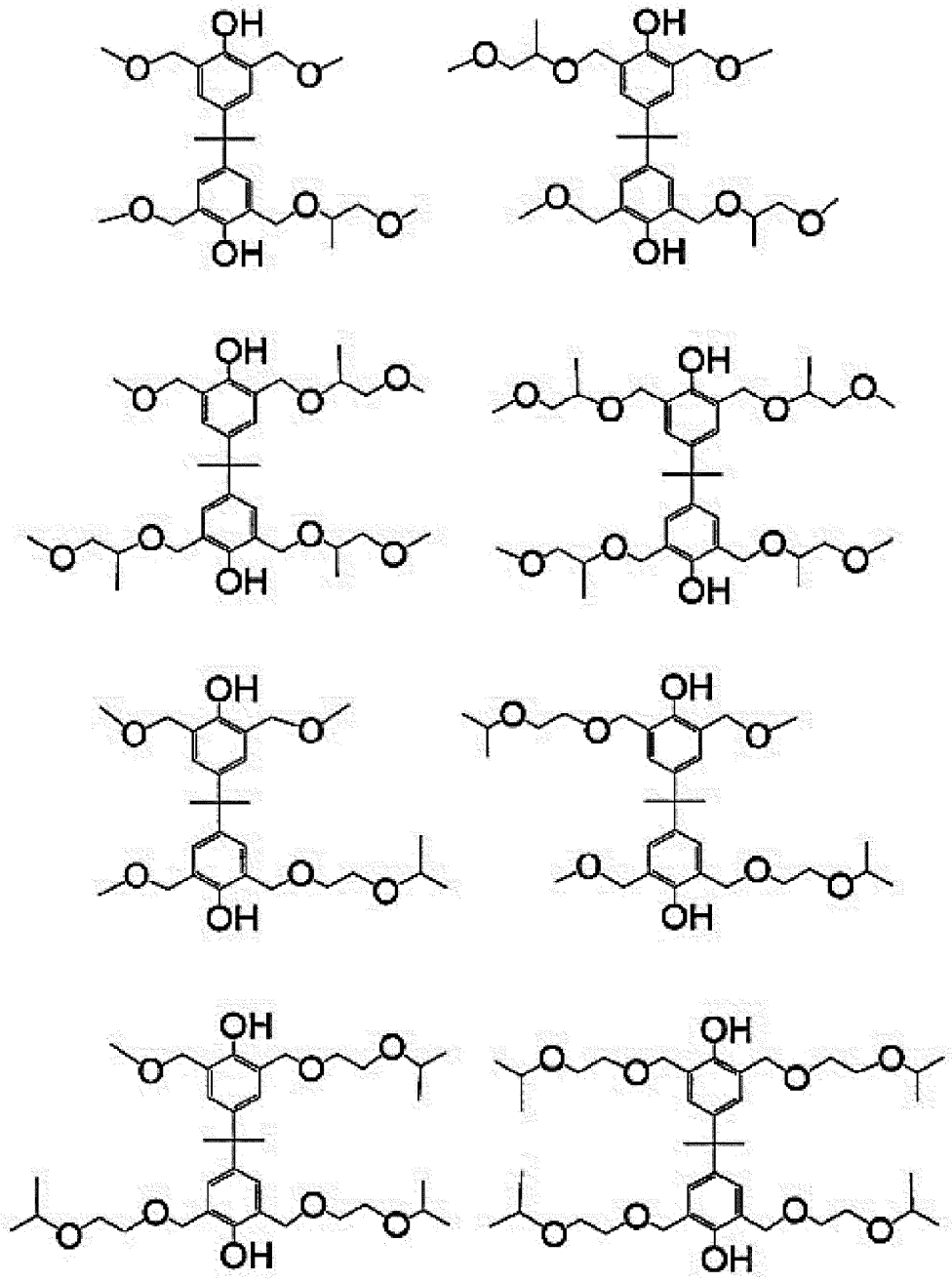
[Chem. 89]



[Chem. 90]



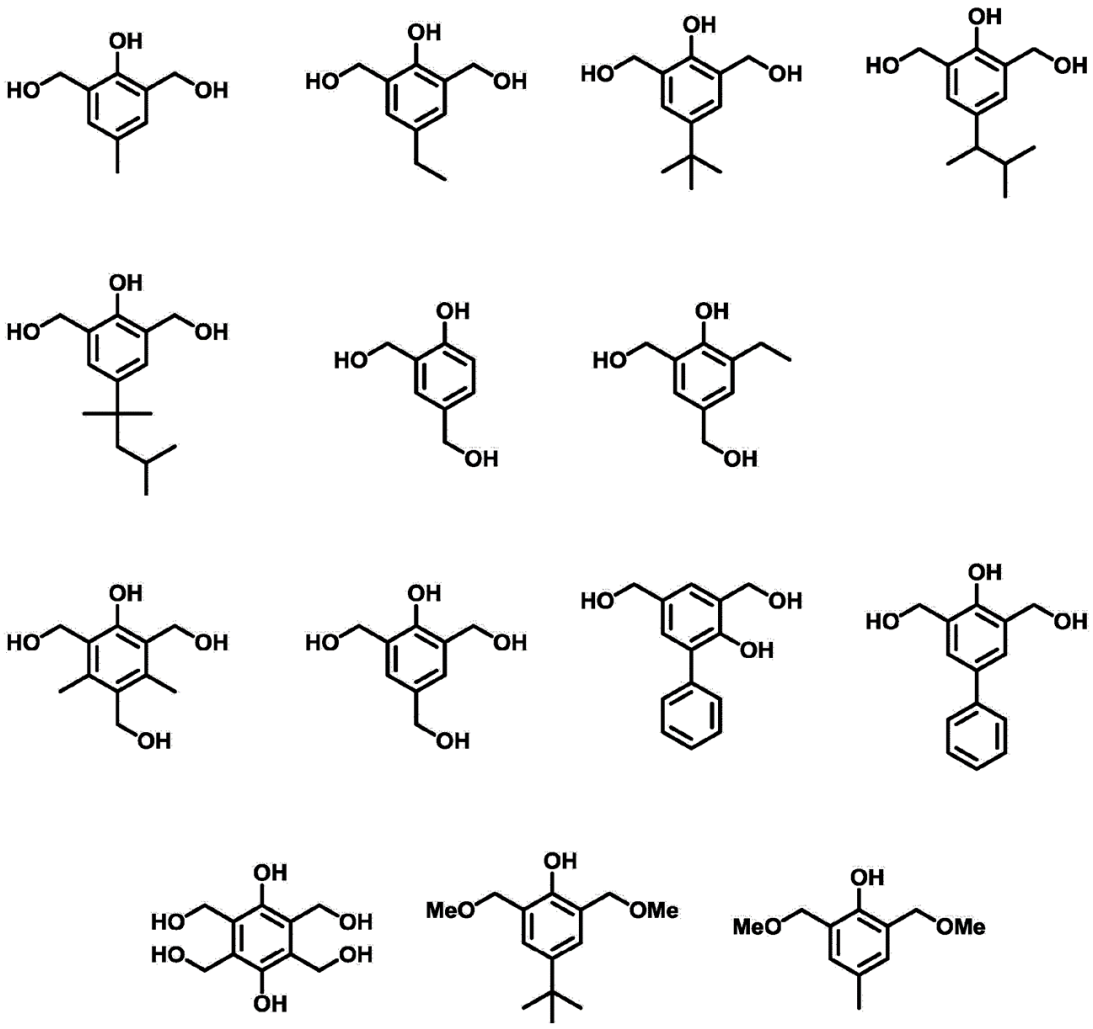
[Chem. 91]



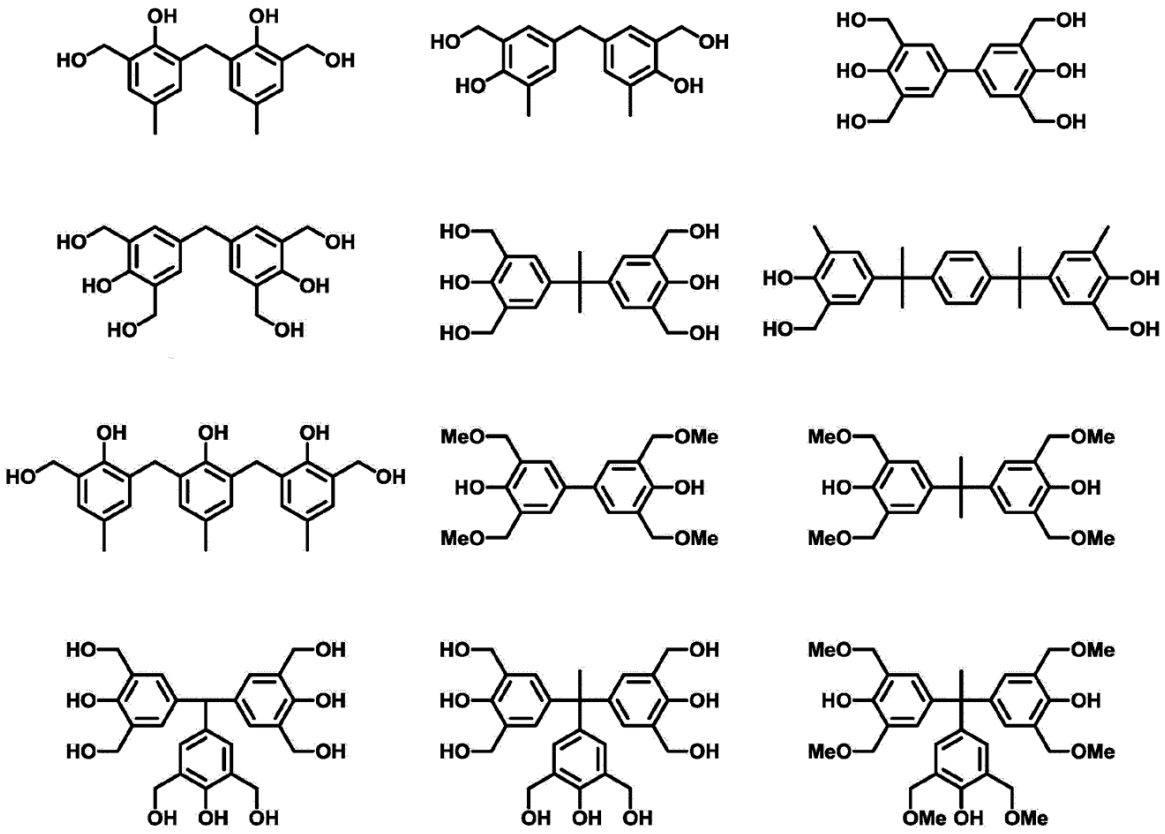
[0231]

Examples of the compound represented by formula (G-3) or formula (G-4) include the following compounds.

[Chem. 92]


OH
HO
OH
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OH
OH
HO
OH
OH
HO
OH
OH
HO
OH
OH
MeO
OMe
OH
MeO
OMe

[Chem. 93]



The compounds are available as products of Asahi Organic Chemicals Industry Co., Ltd. and Honshu Chemical Industry Co., Ltd. Examples of the product include TMOM-BP (trade name) manufactured by Asahi Organic Chemicals Industry Co., Ltd.

[0232]

Among the compounds, the glycoluril compound is preferred. Specifically, tetramethylol glycoluril, tetramethoxy glycoluril, tetramethoxymethyl glycoluril, a compound in which 1 to 4 methylol groups of tetramethylol glycoluril are methoxymethylated or a mixture thereof, and a compound in which 1 to 4 methylol groups of tetramethylol

glycoluril are acyloxymethylated or a mixture thereof are preferred, and tetramethoxymethyl glycoluril is more preferred.

[0233]

The molecular weight of the crosslinking agent is not particularly limited, but is preferably 1,000 or less.

[0234]

The content of the crosslinking agent is, for example, 5 to 70 parts by mass, or 5 to 60 parts by mass, preferably 5 to 45 parts by mass, based on 100 parts by mass of the "compound or polymer". The content of the crosslinking agent is preferably 5 parts by mass or more based on 100 parts by mass of the "compound or polymer" from the viewpoint of the degree of curing of the coating film and prevention of intermixing with the adhesive layer, and is preferably 70 parts by mass or less based on 100 parts by mass of the "compound or polymer" from the viewpoint of solubility in the removing liquid.

[0235]

<<Additive>>

The film-forming component can contain, as additives, a curing catalyst, a surfactant, an adhesion aid, a rheology modifier, and silica particles.

[0236]

As the curing catalyst, both a thermal acid generator

and a photoacid generator can be used, but it is preferable to use a thermal acid generator.

Examples of the thermal acid generator include sulfonic acid compounds and carboxylic acid compounds such as p-toluenesulfonic acid, trifluoromethanesulfonic acid, pyridinium-p-toluenesulfonate (pyridinium-p-toluenesulfonic acid), pyridinium phenolsulfonate, pyridinium p-hydroxybenzenesulfonate (p-phenolsulfonic acid pyridinium salt), pyridinium-trifluoromethanesulfonate, salicylic acid, camphorsulfonic acid, 5-sulfosalicylic acid, 4-chlorobenzenesulfonic acid, 4-hydroxybenzenesulfonic acid, benzenedisulfonic acid, 1-naphthalenesulfonic acid, citric acid, benzoic acid, hydroxybenzoic acid, N-methylmorpholine-p-toluenesulfonate, N-methylmorpholine-p-hydroxybenzenesulfonate, and N-methylmorpholine-5-sulfosalicylate.

[0237]

Examples of the photoacid generator include an onium salt compound, a sulfonimide compound, and a disulfonyldiazomethane compound.

[0238]

Examples of the onium salt compounds include iodonium salt compounds such as diphenyliodonium hexafluorophosphate, diphenyliodonium trifluoromethanesulfonate, diphenyliodonium

nonafluoronormalbutanesulfonate, diphenyliodonium perfluoronormaloctanesulfonate, diphenyliodonium camphorsulfonate, bis(4-tert-butylphenyl)iodonium camphorsulfonate, and bis(4-tert-butylphenyl)iodonium trifluoromethanesulfonate, sulfonium salt compounds such as triphenylsulfonium hexafluoroantimonate, triphenylsulfonium nonafluoronormalbutanesulfonate, triphenylsulfonium camphorsulfonate, and triphenylsulfonium trifluoromethanesulfonate, and the like.

[0239]

Examples of the sulfonimide compound include N-(trifluoromethanesulfonyloxy)succinimide, N-(nonafluoro-n-butanesulfonyloxy)succinimide, N-(camphorsulfonyloxy)succinimide, and N-(trifluoromethanesulfonyloxy)naphthalimide.

[0240]

Examples of the disulfonyldiazomethane compounds include bis(trifluoromethylsulfonyl)diazomethane, bis(cyclohexylsulfonyl)diazomethane, bis(phenylsulfonyl)diazomethane, bis(p-toluenesulfonyl)diazomethane, bis(2,4-dimethylbenzenesulfonyl)diazomethane, and methylsulfonyl-p-toluenesulfonyldiazomethane.

[0241]

Only one type of curing catalyst can be used, or two or

more types thereof can be used in combination.

[0242]

In a case where the curing catalyst is used, the content ratio of the curing catalyst is, for example, 0.1 mass% to 50 mass%, and preferably 1 mass% to 30 mass%, based on the crosslinking agent.

[0243]

The composition for forming a coating film for removing foreign matters may contain a surfactant. Examples of the surfactant include nonionic surfactants including polyoxyethylene alkyl ethers such as polyoxyethylene lauryl ether, polyoxyethylene stearyl ether, polyoxyethylene cetyl ether, and polyoxyethylene oleyl ether, polyoxyethylene alkyl aryl ethers such as polyoxyethylene octylphenol ether and polyoxyethylene nonylphenol ether, polyoxyethylene polyoxypropylene block copolymers, sorbitan fatty acid esters such as sorbitan monolaurate, sorbitan monopalmitate, sorbitan monostearate, sorbitan monooleate, sorbitan trioleate, and sorbitan tristearate, and polyoxyethylene sorbitan fatty acid esters such as polyoxyethylene sorbitan monolaurate, polyoxyethylene sorbitan monopalmitate, polyoxyethylene sorbitan monostearate, polyoxyethylene sorbitan trioleate, and polyoxyethylene sorbitan tristearate, fluorine-based surfactants such as EFTOP EF301, EF303, and EF352 (trade

name, manufactured by Tochem Products Co., Ltd.), MEGAFAC F171 and F173 (trade name, manufactured by DIC Corporation), Fluorad FC430 and FC431 (trade name, manufactured by Sumitomo 3M Limited), Asahi Guard AG710, Surflon S-382, SC101, SC102, SC103, SC104, SC105, and SC106 (trade name, manufactured by AGC Corporation), and an organosiloxane polymer KP341 (trade name, manufactured by Shin-Etsu Chemical Co., Ltd.). The amount of these surfactants is ordinarily 0.2 mass% or less, preferably 0.1 mass% or less based on the total mass of all the components of the composition for forming a coating film for removing foreign matters. These surfactants may be added singly, or two or more types thereof can also be added in combination.

[0244]

The composition for forming a coating film for removing foreign matters may contain silica particles. Examples of the silica particles include a silicone powder having a predetermined mean particle size and a silica sol containing silica having a predetermined mean particle size.

[0245]

Specific examples of the silicone powder include, but are not limited to, Silicone Powder KMP series KMP-600, KMP-601, KMP-602, KMP-605, and X-52-7030 (manufactured by Shin-Etsu Chemical Co., Ltd.).

[0246]

Specific examples of the colloidal silica (silica sol) include, but are not limited to, MA-ST-S (silica sol dispersed in methanol), MT-ST (silica sol dispersed in methanol), MA-ST-UP (silica sol dispersed in methanol), trade name MA-ST-M (silica sol dispersed in methanol), MA-ST-L (silica sol dispersed in methanol), IPA-ST-S (silica sol dispersed in isopropanol), IPA-ST (silica sol dispersed in isopropanol), IPA-ST-UP (silica sol dispersed in isopropanol), IPA-ST-L (silica sol dispersed in isopropanol), IPA-ST-ZL (silica sol dispersed in isopropanol), NPC-ST-30 (silica sol dispersed in n-propyl cellosolve), PGM-ST (silica sol dispersed in 1-methoxy-2-propanol), DMAC-ST (silica sol dispersed in dimethylacetamide), XBA-ST (silica sol dispersed in xylene-n-butanol solvent mixture), trade name EAC-ST (silica sol dispersed in ethyl acetate), PMA-ST (silica sol dispersed in propylene glycol monomethyl ether acetate), MEK-ST (silica sol dispersed in methyl ethyl ketone), MEK-ST-UP (silica sol dispersed in methyl ethyl ketone), MEK-ST-L (silica sol dispersed in methyl ethyl ketone), and MIBK-ST (silica sol dispersed in methyl isobutyl ketone) (all manufactured by Nissan Chemical Corporation).

[0247]

(Coating film for removing foreign matters)

The coating film for removing foreign matters of the present invention is formed from the composition for forming a coating film for removing foreign matters of the present invention.

[0248]

The coating film for removing foreign matters of the present invention can be formed, for example, in the following manner.

The composition for forming a coating film for removing foreign matters of the present invention is applied onto a semiconductor substrate by an appropriate application method, such as methods using a spinner, a coater, and immersion, and then baked to form a coating film for removing foreign matters. The baking conditions are appropriately selected from a baking temperature of 80°C to 300°C, and a baking time of 0.3 to 60 minutes.

[0249]

From the viewpoint of more suitably obtaining the effect of the present invention, the coating film for removing foreign matters is preferably in contact with a metal. Examples of the metal include "metal capable of coordination" described above.

The metal with which the coating film for removing foreign matters is in contact is, for example, a metal present on the semiconductor substrate. Such a metal is,

for example, a metal as an electrode. Examples of the electrode include bumps.

[0250]

The film thickness of the coating film for removing foreign matters is typically 5 nm to 3 μm, preferably 10 nm to 500 nm, most preferably 15 nm to 300 nm.

[0251]

The dissolution rate of the coating film for removing foreign matters to be formed in a removing liquid indicated by the rate of decrease in film thickness is, for example, 0.1 nm to 50 nm per second, preferably 0.2 nm to 40 nm per second, more preferably 0.3 to 20 nm. When the dissolution rate is lower than this range, the time required to remove the coating film for removing foreign matters becomes long, leading to deterioration of productivity.

[0252]

In the coating film for removing foreign matters formed from the composition for forming a coating film for removing foreign matters of the present invention, the dissolution rate of the coating film for removing foreign matters in a removing liquid can be controlled by changing the baking conditions for the formation of the film. As the baking temperature is increased at a constant baking time, a coating film for removing foreign matters having a smaller dissolution rate in a removing liquid can be

formed.

[0253]

The coating film for removing foreign matters may be exposed to light after the film is formed. The surface of a wafer may be fully exposed to light, or may be exposed through a mask having a predetermined pattern. The light exposure may be performed using a KrF excimer laser (wavelength: 248 nm), an ArF excimer laser (wavelength: 193 nm), an F2 excimer laser (wavelength: 157 nm), or the like. After the light exposure, post exposure bake (PEB) may be performed as necessary.

[0254]

(Semiconductor substrate)

The semiconductor substrate of the present invention has the coating film for removing foreign matters of the present invention thereon.

[0255]

From the viewpoint of more suitably obtaining the effect of the present invention, the coating film for removing foreign matters is preferably in contact with a metal. Examples of the metal include “metal capable of coordination” described above.

The metal with which the coating film for removing foreign matters is in contact is, for example, a metal present on the semiconductor substrate. Such a metal is,

for example, a metal as an electrode. Examples of the electrode include bumps.

[0256]

The main material constituting the entire semiconductor substrate is not particularly limited as long as the material is used for this type of application, and examples thereof include silicon, silicon carbide, and a compound semiconductor.

The shape of the semiconductor substrate is not particularly limited, and is, for example, a disk shape. The disk-shaped semiconductor substrate does not need to have a completely circular surface, and for example, the outer periphery of the semiconductor substrate may have a linear portion called an orientation flat or may have a cut called a notch.

The thickness of the disk-shaped semiconductor substrate may be appropriately determined depending on the purpose of use of the semiconductor substrate and the like, and is not particularly limited, and is, for example, 500 to 1,000 μm.

The diameter of the disk-shaped semiconductor substrate may be appropriately determined depending on the purpose of use of the semiconductor substrate and the like, and is not particularly limited, and is, for example, 100 to 1,000 mm.

[0257]

The semiconductor substrate may have an electrode. The electrode is, for example, a bump. The bump is a protruding terminal.

When the semiconductor substrate has an electrode, the semiconductor substrate has an electrode on the support base material side.

In a semiconductor substrate, an electrode is typically formed on a surface on which a circuit is formed. The circuit may be a single layer or a multilayer. The shape of the circuit is not particularly limited.

In the semiconductor substrate, a surface (back surface) opposite to the surface having the electrode is a surface to be processed.

The material, size, shape, structure, and density of the electrode of the semiconductor substrate are not particularly limited.

Examples of the bump include a ball bump, a print bump, a stud bump, and a plating bump.

Typically, the height, radius, and pitch of the bump are appropriately determined from the conditions of a bump height of approximately 1 to 200 μm, a bump radius of 1 to 200 μm, and a bump pitch of 1 to 500 μm.

Examples of the material of the bump include low melting point solder, high melting point solder, tin, indium, gold, silver, and copper. The bump may contain

only a single component or may contain a plurality of components. More specific examples thereof include alloy plating mainly containing Sn, such as SnAg bumps, SnBi bumps, Sn bumps, and AuSn bumps.

In addition, the bump may have a laminated structure including a metal layer made of at least one of these components.

[0258]

An example of the semiconductor substrate is a silicon wafer having a diameter of approximately 300 mm and a thickness of approximately 770 μm.

[0259]

(Method for producing processed semiconductor substrate)

The method for producing a processed semiconductor substrate according to the present invention includes a first step, a second step, a third step, and a fourth step.

The first step is a step of producing a laminate by bonding the semiconductor substrate of the present invention (semiconductor substrate having the coating film for removing foreign matters of the present invention) to a support base material with the coating film for removing foreign matters interposed therebetween.

The second step is a step of processing the laminate.

The third step is a step of peeling off the support

base material from the laminate.

The fourth step is a step of cleaning the semiconductor substrate or the support material with a removing liquid to remove the coating film for removing foreign matters.

In the first embodiment, the coating film for removing foreign matters of the present invention having heat resistance is used as the coating film for removing foreign matter.

[0260]

<First step>

The first step is a step of producing a laminate by bonding the semiconductor substrate of the present invention (semiconductor substrate having the coating film for removing foreign matters of the present invention) to a support base material with the coating film for removing foreign matters interposed therebetween.

[0261]

The support base material is not particularly limited as long as it is a member capable of supporting the semiconductor substrate when the laminate (e.g. the semiconductor substrate) is processed, and examples thereof include a flexible support base material and a glass support base material.

[0262]

The shape of the support base material is not

particularly limited, and examples thereof include a disk shape.

The thickness of the disk-shaped support base material may be appropriately determined depending on the size of the semiconductor substrate and the like, and is not particularly limited, but is, for example, 500 to 1,000 μm.

The diameter of the disk-shaped support base material may be appropriately determined depending on the size of the semiconductor substrate and the like, and is not particularly limited, but is, for example, 100 to 1,000 mm.

[0263]

An example of the support base material is a glass wafer having a diameter of about 300 mm and a thickness of about 700 μm.

[0264]

The first step is preferably a step of producing a laminate by bonding the semiconductor substrate to the support base material with the coating film for removing foreign matters and an adhesive layer interposed therebetween.

[0265]

The adhesive layer is not particularly limited as long as the support base material can be peeled off from the laminate in the third step.

The adhesive layer can be formed by a known adhesive

and a known method. As the adhesive, for example, an application type of wafer temporarily bonding adhesive described in, for example, WO 2015/190438 A, a temporarily bonding material of Thin Materials AG (Nissan Chemical Corporation), a semiconductor wafer temporarily bonding material manufactured by Toray Industries, Inc., WaferBOND (registered trademark) CR-200 and HT-10.10 (manufactured by Brewer Science, Inc.) may be used, or a tape-shaped adhesive (e.g. a back-grinding tape (e.g. 3MTM temporarily fixing pressure-sensitive adhesive tape ATT-4025 (manufactured by 3M Japan Limited), E-series, P-series, S-series (trade names, manufactured by LINTEC Corporation), ICROS Tape (registered trademark) (manufactured by Mitsui Chemicals Tohcello, Inc.)), or a dicing tape (e.g. Solvent Resistance Dicing Tape (trade name, manufactured by Nitto Denko Corporation), a temperature-sensitive adhesive sheet: Intelimer (registered trademark) tape (manufactured by Nitta Corporation), or Intelimer (registered trademark) tape (manufactured by Anchor Techno. Ltd.))) may be used.

A wafer adhesive applied in a specific wafer handling system (e.g. Zero Newton (registered trademark) (manufactured by TOKYO OHKA KOGYO CO., LTD.)) may be used.

As the adhesive layer, one referred to as a pressure-sensitive adhesive layer, a pressure-sensitive adhesive tape, or a temporarily fixing material may be used.

Examples of such an adhesive layer include a pressure-sensitive adhesive layer described in WO 2021/225163 A, an adhesive layer described in WO 2022/065376 A, and a light-curable type adhesive layer described in WO 2022/065388 A.

[0266]

For example, the back-grinding tape includes a base material film, a pressure-sensitive adhesive layer, and a release film. As the base material film, a soft thermoplastic film such as an ethylene-vinyl acetate copolymer (EVA) has been used; however, for the purpose of improving the supporting properties of a wafer, the use of a rigid stretched film, such as polyethylene terephthalate (PET), is being attempted. Thereafter, further improvements have been made, and a design of lamination of two types of films having different moduli, for example, a design of lamination of PET and an ethylene copolymer and a design of lamination of polypropylene (PP) and an ethylene copolymer have been reported.

[0267]

The pressure-sensitive adhesive is generally of an acrylic type. With regard to acrylic type pressure-sensitive adhesives, a design has been known such that cross-linking is caused by reacting a curing agent with an acrylic copolymer from a monomer having a low glass transition temperature, such as butyl acrylate, as the main

raw material. The back-grinding tape is bonded to the wafer circuit surface, and thus, there is a concern about contamination derived from the pressure-sensitive adhesive after peeling the tape. For this reason, there is a report of a design using an emulsion type pressure-sensitive adhesive with the expectation of removal of potentially remaining pressure-sensitive adhesive by cleaning it with water. However, it is difficult to completely remove the remaining pressure-sensitive adhesive. Therefore, the coating film for removing foreign matters of the present application is formed on the circuit surface and then an adhesive layer is formed, and thus foreign matters (residue of the adhesive layer) caused in the subsequent peeling step can be completely removed by cleaning with a removing liquid. Consequently, the wiring portions including circuits are undamaged.

[0268]

The thickness of the adhesive layer is not particularly limited, and is, for example, 5 μm to 500 μm, preferably 10 μm to 300 μm, more preferably 20 μm to 200 μm, particularly preferably 30 μm to 150 μm.

[0269]

Before performing the first step, the adhesive layer may be formed on the coating film for removing foreign matters, may be formed on the support base material, or may

be formed on the semiconductor substrate.

[0270]

When the adhesive layer is not used, the support base material preferably has a pressure-sensitive adhesive layer. The support base material includes, for example, a flexible support and a pressure-sensitive adhesive layer. Examples of the flexible support include a polyimide film. The pressure-sensitive adhesive layer is not particularly limited, and examples thereof include a layer formed from the pressure-sensitive adhesive described above.

[0271]

The bonding is performed, for example, under heating and increased pressure.

The heating temperature is not particularly limited as long as it is normal temperature (25°C) or more, and is typically 50°C or more. From the viewpoint of avoiding excessive heating, the heating temperature is commonly 220°C or less. In some aspects, the heating temperature is 170°C or less.

The load is not particularly limited as long as the substrate and the layer can be bonded and the substrate and the layer are not damaged, and is, for example, 0.5 to 50 kN.

The pressure during bonding is, for example, 0.1 to 20 N/mm^2. The pressure refers to a force (load) per unit area

(mm^2) of the substrate in contact with a jig to which the load is applied.

The degree of pressure reduction is not particularly limited as long as the substrate and the layer can be bonded and the substrate and the layer are not damaged, and is, for example, 10 to 10,000 Pa.

[0272]

When the adhesive layer is used, the layer structure of the laminate produced in the first step may be a semiconductor substrate/coating film for removing foreign matters/adhesive layer/support base material, for the purpose of removing foreign matters as a peeling residue of the adhesive layer together with the coating film for removing foreign matters in the fourth step and achieving a state in which no foreign matters exist on the semiconductor substrate.

In addition, when the adhesive layer is used, the layer structure of the laminate produced in the first step may be a semiconductor substrate/adhesive layer/coating film for removing foreign matters/support base material, for the purpose of removing foreign matters as a peeling residue of the adhesive layer together with the coating film for removing foreign matters in the fourth step and achieving a state in which no foreign matters exist on the support base material. In this case, it is easy to reuse the support

base material.

In addition, the layer structure of the laminate produced in the first step may be a semiconductor substrate/coating film for removing foreign matters/adhesive layer/coating film for removing foreign matters/support base material, for the purpose of, for example, achieving a state in which no foreign matters exist on the semiconductor substrate and the support base material.

[0273]

The laminate produced in the first step may have a laser release layer between the semiconductor substrate and the support base material. When the laminate has a laser release layer, in the third step, for example, the support base material may be peeled off from the laminate by irradiation of the laser release layer with a laser. The laser is applied to the laser release layer from the side of the support base material having laser light transmissivity, for example.

When the laminate has the laser release layer, the layer structure of the laminate produced in the first step may be, for example, a semiconductor substrate/coating film for removing foreign matters/laser release layer/adhesive layer/support base material, for the purpose of removing foreign matters as a peeling residue of the laser release

layer and adhesive layer, together with the coating film for removing foreign matters in the fourth step and achieving a state in which no foreign matters exist on the semiconductor substrate.

When the laminate has the laser release layer, the layer structure of the laminate produced in the first step may be, for example, a semiconductor substrate/adhesive layer/laser release layer/coating film for removing foreign matters/support base material, for the purpose of removing foreign matters as a peeling residue of the laser release layer and the adhesive layer, together with the coating film for removing foreign matters in the fourth step and achieving a state in which no foreign matters exist on the support base material. In this case, it is easy to reuse the support base material.

In the case where a peeling residue of the laser release layer remains on the adhesive layer after peeling off the support base material from the laminate by irradiation of the laser release layer with a laser, foreign matters derived from the laser release layer may be reattached to the semiconductor substrate or the support base material, or the time required to clean the adhesive layer may be increased. For the purpose of preventing these problems and removing the residue of the laser release layer on the adhesive layer, the layer structure of

the laminate produced in the first step may be a semiconductor substrate/adhesive layer/coating film for removing foreign matters/laser release layer/support base material, or a semiconductor substrate/laser release layer/coating film for removing foreign matters/adhesive layer/support base material.

[0274]

<Second step>

The second step is a step of processing the laminate.

The processing in the second step is not particularly limited, and examples thereof include a process of polishing a semiconductor substrate, a process of forming a through electrode of a semiconductor substrate, and a process of connecting a semiconductor substrate and a second semiconductor substrate. The processing in the second step may include one of these processes, or may include two or more of the processes.

[0275]

<<Polishing process>>

The process of polishing a semiconductor substrate is not particularly limited as long as it is a process of polishing the surface of the semiconductor substrate opposite to the surface with the coating film for removing foreign matters to thin the semiconductor substrate, and examples thereof include physical polishing using a

polishing agent or a grindstone.

The polishing process can be performed using a general polishing device used for polishing a semiconductor substrate (e.g. a silicon wafer).

The polishing process results in a reduction in the thickness of the semiconductor substrate, and a semiconductor substrate thinned to a desired thickness is formed. The thickness of the thinned semiconductor substrate is not particularly limited. For example, the thickness may be 30 to 300 μm or 30 to 100 μm.

[0276]

<<Through electrode forming process>>

For example, a through electrode for realizing conduction between thinned semiconductor substrates when a plurality of thinned semiconductor substrates is laminated may be formed on the polished semiconductor substrate.

Accordingly, a through electrode forming process of forming a through electrode on the polished semiconductor substrate after the polishing process and before the peeling step may be included.

The method for forming a through electrode on the semiconductor substrate is not particularly limited, and examples thereof include forming a through hole and filling the formed through hole with a conductive material.

The through hole is formed by, for example,

photolithography.

The filling of the conductive material into the through hole is performed by, for example, a plating technique.

In the second step, the through electrode forming process may be performed without performing the polishing process.

[0277]

<<Connection process>>

The connection process is, for example, a process of connecting the semiconductor substrate to the second semiconductor substrate.

The second semiconductor substrate is not particularly limited, and examples thereof include the semiconductor substrates exemplified in the description of the semiconductor substrate described above.

The connection process is performed, for example, under heating. In addition, the connection process is performed, for example, under increased pressure.

The heating temperature is not particularly limited, and is, for example, 100°C to 350°C.

[0278]

In the connection process, for example, the wiring of the semiconductor substrate is electrically connected to the wiring of the second semiconductor substrate. Such connection is performed, for example, by connecting the

ends of the wiring.

The material, shape, and structure of the wiring in the semiconductor substrate are not particularly limited.

The material, shape, and structure of the wiring in the second semiconductor substrate are not particularly limited.

[0279]

<Third step>

The third step is a step of peeling off the support base material from the laminate. The third step can be said to be a step of separating the semiconductor substrate from the support base material.

Examples of the peeling method include, but are not limited to, solvent peeling, peeling by light irradiation (laser light, non-laser light), mechanical peeling with equipment having a sharp portion (what is called a debonder), and manual peeling between the semiconductor substrate and the support base material.

In particular, in the case where the laminate includes an adhesive layer, and the adhesive layer is an adhesive layer formed using an organic resin that absorbs light and undergoes deterioration necessary for improving the peeling ability, the adhesive layer can be peeled off by, for example, laser irradiation from the support base material side.

The irradiation with the laser light is performed using, for example, ultraviolet light having a wavelength of 190 nm to 400 nm or 190 nm to 600 nm (e.g. 308 nm, 355 nm, or 532 nm).

The peeling can be performed by setting the processing energy density of the pulse laser to about 50 to 500 mJ/cm^2.

When the laminate includes an adhesive layer, peeling commonly occurs inside the adhesive layer or at an interface between the adhesive layer and an adjacent substrate or layer (e.g. a coating film for removing foreign matters). The expression that peeling occurs inside the adhesive layer means that the adhesive layer is cleaved.

[0280]

<Fourth step>

The fourth step is a step of cleaning the semiconductor substrate or the support base material with a removing liquid to remove the coating film for removing foreign matters.

For example, the coating film for removing foreign matters remains on the semiconductor substrate peeled off from the support base material. Thus, the coating film for removing foreign matters is removed with a removing liquid.

In the fourth step, for example, foreign matters are

removed together with the coating film for removing foreign matters.

In the fourth step, for example, foreign matters, which are peeling residues of the adhesive layer, are removed together with the coating film for removing foreign matters.

[0281]

Examples of the removing liquid include the removing liquids exemplified in the description of the composition for forming a coating film for removing foreign matters of the present invention.

The cleaning method is not particularly limited, and examples thereof include a method for immersing, in a removing liquid, the semiconductor substrate on which the coating film for removing foreign matters remains, and a method for spraying a removing liquid onto the semiconductor substrate on which the coating film for removing foreign matters remains.

Conditions for cleaning are not particularly limited. For example, the temperature of the cleaning liquid is 5°C to 50°C. The cleaning time is appropriately selected from 2 to 500 seconds or 3 to 400 seconds.

[0282]

For example, it is preferable that the coating film for removing foreign matters can be easily peeled off at room

temperature (e.g. 25°C) using a widely used 2.38-mass% tetramethylammonium hydroxide aqueous solution.

[0283]

An example of the method for producing a processed semiconductor substrate will be described with reference to the drawings.

First, a semiconductor substrate 11 is prepared (Fig. 1A).

Then, a coating film for removing foreign matters 12 is formed on the semiconductor substrate 11 (Fig. 1B).

Then, the semiconductor substrate 11 including the coating film for removing foreign matters 12 illustrated in Fig. 1B and a support base material 14 including a flexible support 14A and a pressure-sensitive adhesive layer 14B are bonded such that the coating film for removing foreign matters 12 and the pressure-sensitive adhesive layer 14B face each other (Fig. 1C).

Then, the surface of the semiconductor substrate 11 opposite to the surface on the side of the coating film for removing foreign matters 12 is polished to thin the semiconductor substrate 11 (Fig. 1D).

Then, the support base material 14 is separated from the semiconductor substrate 11 (Figs. 1E and 1F).

A peeling residue 14C of the pressure-sensitive adhesive layer 14B remains on the coating film for removing

foreign matters 12 after separation (Fig. 1F). Thus, the coating film for removing foreign matters 12 is removed with a removing liquid (Fig. 1G). This makes it possible to prevent peeling residue 14C, which is a foreign matter, from remaining on the semiconductor substrate 11.

[0284]

The other example of the method for producing a processed semiconductor substrate will be described with reference to the drawings.

First, a semiconductor substrate 1 having wiring 1A is prepared (Fig. 2A).

Next, a coating film 2 for removing foreign matters is formed on the semiconductor substrate 1 (Fig. 2B).

Meanwhile, a glass substrate 4 having an adhesive layer 3 formed on the surface thereof is prepared (Fig. 2C).

Then, the semiconductor substrate 1 including the coating film 2 for removing foreign matters illustrated in Fig. 2B and the glass substrate 4 including the adhesive layer 3 illustrated in Fig. 2C are bonded such that the coating film 2 for removing foreign matters and the adhesive layer 3 face each other (Figs. 2D and 2E).

Then, the surface of the semiconductor substrate 1 opposite to the surface on the side of the coating film 2 for removing foreign matters is polished to thin the semiconductor substrate 1 (Fig. 2F). Then, the wiring 1A

is exposed.

Then, the laminate illustrated in Fig. 2F and a second semiconductor substrate 5 having wiring 5A are bonded such that the surface of the semiconductor substrate 1 opposite to the surface on the side of the coating film 2 for removing foreign matters faces the surface of the second semiconductor substrate 5 on which the wiring 5A is exposed (Figs. 2G and 2H).

Subsequently, the adhesive layer 3 and the glass substrate 4 are separated from the semiconductor substrate 1 (Fig. 2I). The separation can be easily performed, for example, by irradiating the adhesive layer 3 with a laser to lower the adhesive force of the adhesive layer 3.

A peeling residue 3A of the adhesive layer 3 remains on the coating film 2 for removing foreign matters after separation (Figs. 2I and 2J). Thus, the coating film 2 for removing foreign matters is removed with a removing liquid (Fig. 2K). This makes it possible to prevent peeling residue 3A, which is a foreign matter, from remaining on the semiconductor substrate 1.

[0285]

The method for producing a processed semiconductor substrate of the present invention can be suitably used for hybrid bonding to connect semiconductor substrates to each other.

[0286]

<Another embodiment>

An embodiment of the present invention may be a method for removing pre-existing foreign matters on a substrate for semiconductor production. For example, WO 2017/056746 A and WO 2020/008965 A disclose a composition for forming a substrate treatment film and a method for treating a substrate, which can efficiently remove minute particles from the substrate surface and easily remove the formed substrate treatment film from the substrate surface, in a process for forming a substrate treatment film on the surface of the semiconductor substrate and removing foreign matters from this substrate surface. The composition for forming a coating film for removing foreign matters of the present invention can also be used in the same method/application as described above.

[0287]

One of the above-described examples will be specifically described below. In this application example, the composition for forming a coating film for removing foreign matters of the present invention is used as a composition for forming a coating film on a semiconductor substrate. First, a step of forming a coating film is performed. That is, the composition for forming a coating film for removing foreign matters is applied onto the

semiconductor substrate to form a coating film. The semiconductor substrate may be what is called a bare substrate (flat), which is in an unprocessed state or a state in which various films are formed, or may be one in which shapes such as wiring are processed for semiconductor device production. Coating methods include, for example, rotary coating (spin coating), cast coating, and roll coating. The coated film is then heated (baked) and/or depressurized to efficiently remove a part or all of the solvent contained in the coated film, thereby accelerating solidification and/or curing of the solid content contained in the coated film. The term "solidification" as used herein means becoming solid, and the term "curing" means an increase in molecular weight (e.g. cross-linking or polymerization) due to the linkage of molecules. In this manner, a coating film is formed. In this process, particles adhering to the circuit of the semiconductor substrate are incorporated into the coating film and efficiently separated from the circuit, or the like. Then, a step of removing a coating film is performed. Specifically, the coating film is entirely removed from the semiconductor substrate by supplying, onto the coating film, a removing liquid that dissolves the coating film. As a result, the particles are removed from the semiconductor substrate together with the coating film.

Examples

[0288]

Then, the contents of the present invention will be specifically described with reference to synthesis examples and examples, but the present invention is not limited thereto.

[0289]

<Example 1>

0.04 g of 1,1,1-tris (4-hydroxyphenyl)ethane (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.36 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0290]

<Example 2>

0.09 g of salicylaldoxime (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.31 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0291]

<Example 3>

0.06 g of tartaric acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0292]

<Example 4>

0.06 g of citric acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0293]

<Example 5>

0.06 g of 3-methyl-1-phenyl-5-pyrazolone (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having

a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0294]

<Example 6>

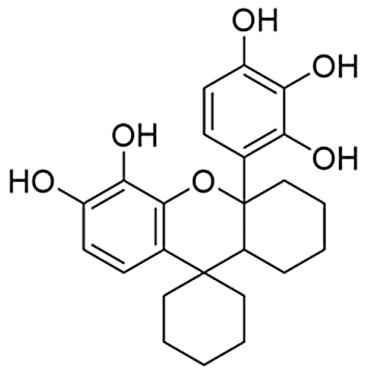
0.06 g of L-ascorbic acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0295]

<Example 7>

0.06 g of pyrogallol FZ (Honshu Chemical Industry Co., Ltd., the following structure) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[Chem. 94]



[0296]

<Example 8>

0.06 g of curcumin (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0297]

<Example 9>

0.06 g of malonic acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0298]

<Example 10>

0.06 g of meso-butane-1,2,3,4-tetracarboxylic acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0299]

<Example 11>

0.06 g of 1,2,3,4-cyclopentanetetracarboxylic acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0300]

<Example 12>

0.06 g of thiazole-4-carboxylic acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-

hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0301]

<Example 13>

0.06 g of gallic acid (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0302]

<Example 14>

0.06 g of methyl gallate (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0303]

<Example 15>

0.06 g of picolinic acid (Tokyo Chemical Industry Co.,

Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0304]

<Example 16>

0.06 g of N,N'-bis(salicylidene)-1,3-propanediamine (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0305]

<Example 17>

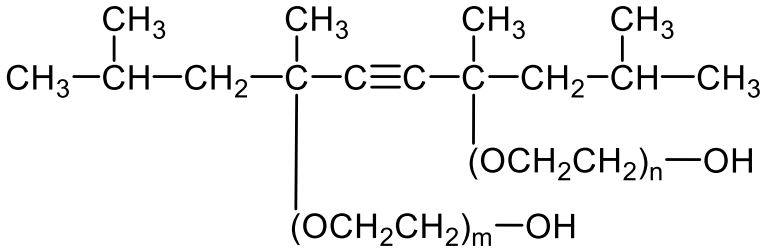
0.06 g of tris(2-hydroxyethyl)isocyanurate (Tokyo Chemical Industry Co., Ltd.) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0306]

<Example 18>

0.06 g of OLFIN E1010 (Nissin Chemical Industry Co., Ltd., the following structure) and 98.60 g of propylene glycol monomethyl ether were added to 1.33 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[Chem. 95]



n, m: average number of added moles of 10

[0307]

<Comparative Example 1>

98.60 g of propylene glycol monomethyl ether was added to 1.40 g of polypara-hydroxystyrene (VP-8000, Nippon Soda Co., Ltd.), and then the mixture was filtered using a PTFE syringe filter having a pore size of 0.20 μm to prepare a composition for forming a coating film for removing foreign matters.

[0308]

[Alkali solubility test]

As evaluation of solubility in an alkaline solution, each of the compositions for forming a coating film for removing foreign matters prepared in Examples 1 to 18 and Comparative Example 1 was applied to a 150 nm-thick copper vapor deposition substrate, and heated at 160°C for 1 minute to form a coating film having a film thickness of 40 nm. The copper substrate coated with the composition for forming a coating film for removing foreign matters was immersed in a 2.38% tetramethylammonium hydroxide aqueous solution (NMD-3, manufactured by TOKYO OHKA KOGYO CO., LTD.) for 30 seconds, washed with pure water, and then visually evaluated for the presence or absence of a coating film. The results of the solubility test in an alkaline solution are shown in Table 1. It is to be noted that the evaluation criteria "o" indicate favorable alkali solubility and excellent removability with an alkali solution. The evaluation criteria "△" can be said to indicate alkali solubility, and indicate an acceptable level.

(Evaluation criteria)

o: No coating film remained

△: Only a part of the coating film remained

×: A coating film remained.

[0309]

[Table 1]

	Evaluation results of alkali solubility
Example 1	○
Example 2	○
Example 3	○
Example 4	○
Example 5	○
Example 6	○
Example 7	○
Example 8	○
Example 9	△
Example 10	△
Example 11	△
Example 12	△
Example 13	△
Example 14	△
Example 15	△
Example 16	△
Example 17	△
Example 18	△
Comparative Example 1	×

Reference Signs List

[0310]

1 Semiconductor substrate

1A Wiring

2 Coating film for removing foreign matters

3 Adhesive layer

4 Glass substrate

5 Second semiconductor substrate

5A Wiring

11 Semiconductor substrate

12 Coating film for removing foreign matters

14 Support base material

14A Flexible support

14B Pressure-sensitive adhesive layer

14C Peeling residue

CLAIMS

[claim 1] A composition for forming a coating film for removing foreign matters capable of forming a coating film removable by a removing liquid, the composition comprising:

a film-forming component; and a solvent,

wherein the film-forming component includes a coordinating compound.

[claim 2] The composition according to claim 1, wherein the coordinating compound is a compound capable of coordinating to copper.

[claim 3] The composition according to claim 1,

wherein the coordinating compound is at least one of:

(I) a compound having two or more hydroxy groups;

(II) a compound having two or more carboxy groups;

(III) a compound having a heterocyclic ring; and

(IV) an acetylene glycol compound.

[claim 4] The compound according to claim 1, wherein the film-forming component includes a compound or a polymer as a component other than the coordinating compound.

[claim 5] The composition according to claim 4, wherein the compound or polymer has at least one of a hydroxy group, a carboxy group, and a heterocyclic ring.

[claim 6] The composition according to claim 1, wherein a content of the coordinating compound is 1 mass% to 10 mass% based on the film-forming component.

[claim 7] The composition according to claim 4, wherein a content of the compound or polymer is 90 mass% to 99 mass% based on the film-forming component.

[claim 8] The composition according to claim 1, wherein the removing liquid is an alkaline removing liquid.

[claim 9] The composition according to claim 1, wherein the coating film is in contact with copper.

[claim 10] A coating film for removing foreign matters, formed from the composition according to any one of claims 1 to 9.

[claim 11] A semiconductor substrate comprising the coating film for removing foreign matters according to claim 10.

[claim 12] The semiconductor substrate according to claim 11, wherein the coating film for removing foreign matters is in contact with copper.

[claim 13] A method for producing a processed semiconductor substrate, comprising:

a first step of producing a laminate by bonding the semiconductor substrate according to claim 11 to a support base material with the coating film for removing foreign matters interposed therebetween;

a second step of processing the laminate;

a third step of peeling off the support base material from the laminate; and

a fourth step of cleaning the semiconductor substrate or the support base material with a removing liquid to remove the coating film for removing foreign matters.

[claim 14] The method for producing a processed semiconductor substrate according to claim 13, wherein the coating film for removing foreign matters is in contact with copper in the laminate.

[claim 15] The method for producing a processed semiconductor substrate according to claim 13, wherein in the fourth step, the foreign matters are removed together with the coating film for removing foreign matters.

[claim 16] The method for producing a processed semiconductor substrate according to claim 13, wherein the first step is a step of producing a laminate by bonding the semiconductor substrate to the support base material with the coating film for removing foreign matters and an adhesive layer interposed therebetween.

[claim 17] The method for producing a semiconductor substrate according to claim 16, wherein in the fourth step, foreign matters, which are peeling residues of the adhesive layer, are removed together with the coating film for removing foreign matters.

[claim 18] The method for producing a processed semiconductor substrate according to claim 13, wherein the processing includes connecting the semiconductor substrate

to a second semiconductor substrate.