RADIATION-SENSITIVE COMPOSITION FOR FORMING A COLORING LAYER, COLOR FILTER, AND COLOR LIQUID CRYSTAL DISPLAY DEVICE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001]

The present invention relates to a radiation-sensitive composition for forming a coloring layer, a color filter, and a liquid crystal display device. More specifically, the present invention relates to a radiation-sensitive composition used for forming a coloring layer which is useful for a color filter used for a transmission-type or reflection-type color liquid crystal display apparatus, a color image pickup tube element, or the like, a color filter provided with the coloring layer formed by using the radiation-sensitive composition, and a color liquid crystal display device including the color filter.

2. Description of the Related Art

[0002]

In producing a color filter using a colored radiation-sensitive composition, generally, a method of obtaining a pixel pattern of each color is known, involving: forming a coating film of a colored radiation-sensitive composition on a substrate or on a substrate on which a light-shielding layer having a desired pattern is previously formed; irradiating the

coating film through a photomask having a desired pattern form (hereinafter, referred to as "exposure"); developing the resultant to thereby dissolve and remove an unexposed part; and then post-baking the resultant (for example, refer to Patent Documents 1 and 2).

[0003]

Then, in recent years, there has been demanded a bright screen with good color reproducibility for monitors or televisions, and there has occurred a necessity, along with enhancement in the brightness of a backlight, to increase the content of a colorant, in particular the content of a pigment contained in the radiation-sensitive composition (Non-Patent Document 1). In addition, there is a tendency that liquid crystal monitor screens and liquid crystal television screens are made more high-definition, resulting in increasing the number of pixels per unit area on the screen. Therefore, there have been demanded a radiation-sensitive composition for forming a black matrix and a radiation-sensitive composition for forming a pixel, both of which are capable of forming finer patterns.

[0004]

In view of the above-mentioned demands, it is disclosed in Patent Document 3, for example, that a pattern having high resolution may be formed by incorporating an alkali-soluble resin having a specific structure into a radiation-sensitive

composition. However, in a so-called negative type radiation-sensitive composition, there has been a problem in that the line width of the pattern to be formed has become thicker than the designed size of a photomask due to the influence of a diffracted light at the time of proximity exposure, and thus, a fine pattern having a desired line width could not have been obtained.

On the other hand, as means for solving the thickening of the pattern line width of the negative type radiation-sensitive composition, there are known methods of decreasing an exposure dose, intensifying development conditions, and decreasing the content of a radiation-sensitive polymerization initiator contained in the radiation-sensitive composition or incorporating a polymerization inhibitor into the radiation-sensitive composition, for example. However, there has been a tendency that chipping, peeling, or undercut in the pattern more easily occurs at the time of development in all of those means, and they have been totally inapplicable to, in particular, the case where the content of a colorant contained in the radiation-sensitive composition becomes high.

[Patent Document 1] JP-A-02-144502

[Patent Document 2] JP-A-03-53201

[Patent Document 3] JP-A-2004-205862

[Non-Patent Document 1] "Novel development of front/backlight for LCD" written by Masakazu Murakami, first

edition, TORAY RESEARCH CENTER, Inc., published in September, 2002)

SUMMARY OF THE INVENTION

[0005]

It is an object of the present invention to provide a radiation-sensitive composition for forming a coloring layer, which is excellent in adhesion to a substrate even in the case where the content of a colorant contained in the radiation-sensitive composition is high, may form a pixel and a black matrix each having a high-definition and excellent pattern form, and is free from a pattern line width being thickened even in proximity exposure.

It is also an object of the present invention to provide a color filter including the coloring layer formed by using the radiation-sensitive composition, and a color liquid crystal display device including the color filter.

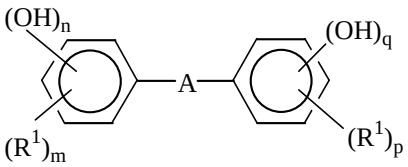
[0006]

In view of the circumstances described above, the inventors of the present invention have conducted intensive studies, and have found that the above problems may be solved by incorporating a phenolic compound having a specific structure into a radiation-sensitive composition for forming a coloring layer. Thus, the present invention has been accomplished.

[0007]

In other words, the present invention provides a radiation-sensitive composition for forming a coloring layer containing: a colorant (A); an alkali-soluble resin (B); a monomer having two or more radical polymerizable unsaturated bonds (C); a radiation-sensitive radical generating agent (D); and at least one kind of compound (E), which is selected from the group consisting of: compounds represented by the following formulae (1) to (5):

[0008]

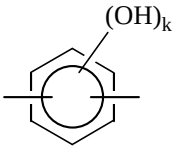


(1)

[0009]

where: R^1's each represent a hydrogen atom, an alkyl group having 4 or less carbon atoms, an alkoxy group having 4 or less carbon atoms, a phenyl group, a naphthyl group, or a $-(CH_2)_x$-COOZ group, and a plurality of R^1's may be identical to or different from each other; Z represents an alkoxyalkyl group, a cyclic ether group, a vinyloxyalkyl group, or a t-alkoxycarbonylalkyl group, and a plurality of Z's may be identical to or different from each other; x represents an integer of 0 to 4; A represents a single bond, an -S- group, an -O- group, a -CO- group, a -COO- group, an -SO- group, an $-SO_2$- group, a $-C(R^2)(R^3)$- group, or a

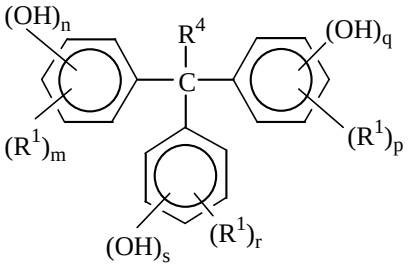
[0010]



[0011]

group provided that k represents an integer of 0 to 4; R^2 and R^3 may be identical to or different from each other and each represent a hydrogen atom, an alkyl group having 6 or less carbon atoms, an acyl group having 6 or less carbon atoms, a phenyl group, a naphthyl group, or a $-(CH_2)_x-COOZ$ group; and m, n, p, and q each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, and $n+q \geq 1$;

[0012]

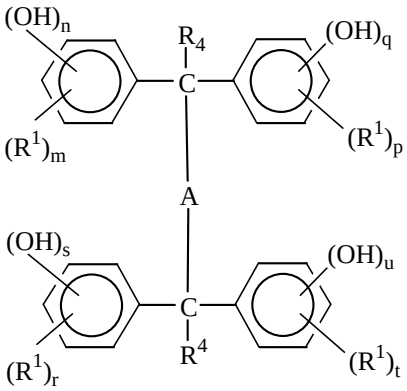


(2)

[0013]

where: R^1's each represent the same group as R^1 in the formula (1); R^4 represents the same group as R^2 in the formula (1); and m, n, p, q, r, and s each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, $r+s \leq 5$, and $n+q+s \geq 1$;

[0014]

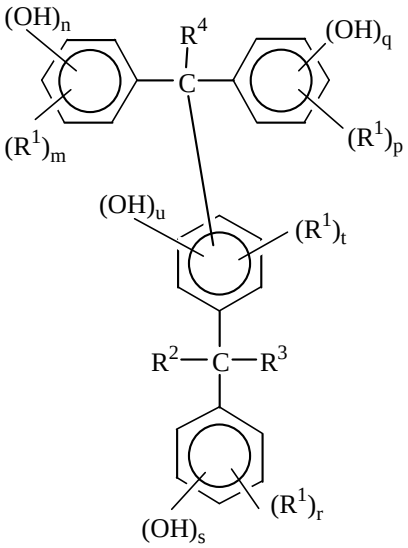


(3)

[0015]

where: R^1's each represent the same group as R^1 in the formula (1); R^4's each represent the same group as R^2 in the formula (1) and two R^4's may be identical to or different from each other; A represents the same group as A in the formula (1); and m, n, p, q, r, s, t, and u each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, $r+s \leq 5$, $t+u \leq 5$, and $n+q+s+u \geq 1$;

[0016]



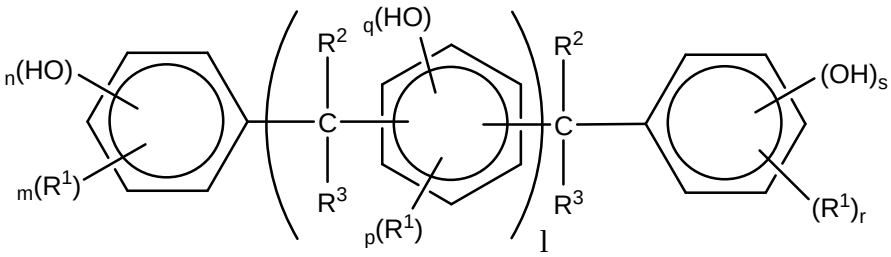
(4)

[0017]

where: R^1's each represent the same group as R^1 in the

formula (1); R^2, R^3, and R^4 represent the same groups as R^2 in the formula (1), R^3 in the formula (1), and R^4 in the formula (2), respectively; and m, n, p, q, r, s, t, and u each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, $r+s \leq 5$, $t+u \leq 4$, and $n+q+s+u \geq 1$; and

[0018]



(5)

[0019]

where: R^1's, R^2's, and R^3's represent the same groups as R^1, R^2, and R^3 in the formula (1), respectively; m, n, p, q, r, and s each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 4$, $r+s \leq 5$, and $n+q+s \geq 2$; and l represents an integer of 1 to 5;

a phenolic compound having a flavan structure; a phenolic compound having a spirobiindane structure; and a phenolic compound having a spirobiindene structure.

[0020]

Further, the present invention also provides a color filter, which has a coloring layer formed by using the radiation-sensitive composition for forming a coloring layer, and a color liquid crystal display device, which includes the color filter.

[0021]

By using the radiation-sensitive composition containing the component (E) of the present invention, the composition is excellent in adhesion to a substrate even in the case where the content of a colorant contained in the radiation-sensitive composition is high, may form a pixel and a black matrix each having a high-definition and excellent pattern form, and is free from a pattern line being thickened even in proximity exposure.

Thus, the color filter of the present invention is useful for a transmission-type or reflection-type color liquid crystal display device, a color image pickup tube element, a color sensor, or the like.

DETAILED DESCRIPTION OF THE INVENTION

[0022]

(Radiation-sensitive composition for forming coloring layer)

The "coloring layer" as used in a radiation-sensitive composition for forming a coloring layer (hereinafter may be simply referred to as "radiation-sensitive composition") of the present invention means a layer formed of a pixel and/or a black matrix used for a color filter.

Hereinafter, the constituent components of the radiation-sensitive composition for forming a coloring layer of the

present invention are described.

[0023]

-Colorant (A)-

The colorant (A) used in the present invention is not particularly limited, and may include organic pigments or inorganic pigments.

As the colorant (A), examples of organic pigments include compounds classified as pigments according to color index (C.I.; The Society of Dyers and Colourists), specifically include compounds having the following color index (C.I.) numbers:

[0024]

C.I. Pigment Yellow 12, C.I. Pigment Yellow 13, C.I. Pigment Yellow 14, C.I. Pigment Yellow 17, C.I. Pigment Yellow 20, C.I. Pigment Yellow 24, C.I. Pigment Yellow 31, C.I. Pigment Yellow 55, C.I. Pigment Yellow 83, C.I. Pigment Yellow 93, C.I. Pigment Yellow 109, C.I. Pigment Yellow 110, C.I. Pigment Yellow 138, C.I. Pigment Yellow 139, C.I. Pigment Yellow 150, C.I. Pigment Yellow 153, C.I. Pigment Yellow 154, C.I. Pigment Yellow 155, C.I. Pigment Yellow 166, C.I. Pigment Yellow 168, and C.I. Pigment Yellow 211;

[0025]

C.I. Pigment Orange 5, C.I. Pigment Orange 13, C.I. Pigment Orange 14, C.I. Pigment Orange 24, C.I. Pigment Orange 34, C.I. Pigment Orange 36, C.I. Pigment Orange 38, C.I.

Pigment Orange 40, C.I. Pigment Orange 43, C.I. Pigment Orange 46, C.I. Pigment Orange 49, C.I. Pigment Orange 61, C.I. Pigment Orange 64, C.I. Pigment Orange 68, C.I. Pigment Orange 70, C.I. Pigment Orange 71, C.I. Pigment Orange 72, C.I. Pigment Orange 73, and C.I. Pigment Orange 74;

[0026]

C.I. Pigment Red 1, C.I. Pigment Red 2, C.I. Pigment Red 5, C.I. Pigment Red 17, C.I. Pigment Red 31, C.I. Pigment Red 32, C.I. Pigment Red 41, C.I. Pigment Red 122, C.I. Pigment Red 123, C.I. Pigment Red 144, C.I. Pigment Red 149, C.I. Pigment Red 166, C.I. Pigment Red 168, C.I. Pigment Red 170, C.I. Pigment Red 171, C.I. Pigment Red 175, C.I. Pigment Red 176, C.I. Pigment Red 177, C.I. C.I. Pigment Red 178, C.I. Pigment Red 179, Pigment Red 180, C.I. Pigment Red 185, C.I. Pigment Red 187, C.I. Pigment Red 202, C.I. Pigment Red 206, C.I. Pigment Red 207, C.I. Pigment Red 209, C.I. Pigment Red 214, C.I. Pigment Red 220, C.I. Pigment Red 221, C.I. Pigment Red 224, C.I. Pigment Red 242, C.I. Pigment Red 243, C.I. Pigment Red 254, C.I. Pigment Red 255, C.I. Pigment Red 262, C.I. Pigment Red 264, and C.I. Pigment Red 272;

[0027]

C.I. Pigment Violet 1, C.I. Pigment Violet 19, C.I. Pigment Violet 23, C.I. Pigment Violet 29, C.I. Pigment Violet 32, C.I. Pigment Violet 36, and C.I. Pigment Violet 38;

C.I. Pigment Blue 15, C.I. Pigment Blue 15:3, C.I.

Pigment Blue 15:4, C.I. Pigment Blue 15:6, C.I. Pigment Blue 60, and C.I. Pigment Blue 80;

C.I. Pigment Green 7, C.I. Pigment Green 36, and C.I. Pigment Green 58;

C.I. Pigment Brown 23 and C.I. Pigment Brown 25; and

C.I. Pigment Black 1 and C.I. Pigment Black 7.

[0028]

In the present invention, the organic pigment may be purified by a recrystallization method, a reprecipitation method, a solvent cleaning method, a sublimination method, a vacuum heating method, or a combination thereof.

[0029]

Further, examples of the inorganic pigment include titanium oxide, barium sulfate, calcium carbonate, zinc oxide, lead sulfate, yellow lead, zinc yellow, blood red (red iron oxide (III)), cadmium red, ultramarine blue, prussian blue, chromium oxide green, cobalt green, amber, titanium black, synthetic iron black, and carbon black.

[0030]

In those colorants, the surface of the colorant particle may be modified with a polymer as required. Examples of the polymer for modifying the surface of the colorant include a polymer disclosed in JP 08-259876 A and various commercially available polymers or oligomers for dispersing a pigment. The methods of coating a carbon black surface with a polymer are

disclosed, for example, in JP-A-09-71733, JP-A-09-95625, and JP-A-09-124969.

The colorants may be used alone or in a mixture of two or more.

[0031]

In the case where the radiation-sensitive composition of the present invention is used for forming a pixel, because there are required high-definition color development and heat resistance for the pixel, it is preferable to use as the colorant (A) a colorant having high color developability and high heat resistance, in particular a colorant having high resistance to thermal decomposition. Specifically an organic colorant, and in particular an organic pigment are preferred as the colorant (A).

On the other hand, in the case where the radiation-sensitive composition of the present invention is used for forming a black matrix, because there is required light-shielding property for the black matrix, an organic pigment or a carbon black is preferably used as the colorant (A).

[0032]

According to the radiation-sensitive composition of the present invention, even in the case where the content of the colorant is 30 wt% or more with respect to the total solid content of the radiation-sensitive composition, the composition may form a pattern in which chipping or peeling

does not occur and which is free from its line width being thickened. Further, in the present invention, the upper limit of the content of the colorant is, from the viewpoint of maintaining a development property, preferably 60 wt% or less and particularly preferably 50 wt% or less with respect to the total solid content of the radiation-sensitive composition. Here, the solid content refers to a component other than the solvents to be described later.

[0033]

The colorant of the present invention may be used together with, as desired, a dispersant and a dispersion aid.

Examples of the dispersant include any appropriate dispersants such as a cationic dispersant, an anionic dispersant, a nonionic dispersant, and an amphoteric dispersant, and a polymer dispersant is preferred. Specific examples thereof include a modified acrylic copolymer, an acrylic copolymer, a polyurethane, a polyester, an alkyl ammonium salt or a phosphate salt of a high molecular copolymer, and a cationic comb graft polymer. Here, the cationic comb graft polymer refers to a polymer having a structure in which a branch polymer having two or more molecules is graft bonded to one molecule of trunk polymer having a plurality of basic groups (cationic functional groups). For example, a polymer constituted of a ring-opened polymer in which the truck polymer part is polyethyleneimine

and the branch polymer part is ε-caprolactone may be given. Of those dispersants, preferred are a modified acrylic copolymer, a polyurethane, and a cationic comb graft polymer.

[0034]

These dispersants are commercially available. Examples of the modified acrylic copolymers include Disperbyk-2000 and Disperbyk-2001 (both manufactured by BYK Japan KK); examples of the polyurethanes include Disperbyk-161, Disperbyk-162, Disperbyk-165, Disperbyk-167, Disperbyk-170, and Disperbyk-182 (all manufactured by BYK Japan KK), EFKA4046 (manufactured by Ciba Specialty Chemicals Co., Ltd.), and Solsperse 76500 (manufactured by The Lubrizol Corporation); and examples of the cationic comb graft polymers include Solsperse 24000 (manufactured by The Lubrizol Corporation), and Ajisper-PB821 and Ajisper-PB822 (manufactured by Ajinomoto Fine-Techno Co., Inc.).

[0035]

The above dispersants may be used alone or in a mixture of two or more. The content of the dispersant is generally 100 parts by weight or less, preferably 0.5 to 100 parts by weight, more preferably 1 to 70 parts by weight, and particularly preferably 10 to 50 parts by weight, with respect to 100 parts by weight of the colorant (A). In this case, when the content of the dispersant exceeds 100 parts by weight, developability or the like may be impaired.

[0036]

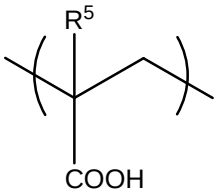
Examples of the dispersion aid include a blue pigment derivative and a yellow pigment derivative, and a specific example thereof includes a copper phthalocyanine derivative.

[0037]

-Alkali-soluble resin (B)-

The alkali-soluble resin (B) to be incorporated into the radiation-sensitive composition of the present invention is not particularly limited as long as the alkali-soluble resin has a solubility to an alkalin developer to be used in a development treatment step in forming a coloring layer, and is generally a polymer having an acidic functional group such as a carboxyl group or a phenolic hydroxyl group. Of those, preferred is an alkali-soluble resin containing a polymer having a carboxyl group, and particularly preferred is a polymer containing at least one kind selected from the group consisting of a polymer represented by the following formula (6) (hereinafter referred to as "polymer (B1)") and a polymer represented by the following formula (7) (hereinafter referred to as "polymer (B2)"):

[0038]

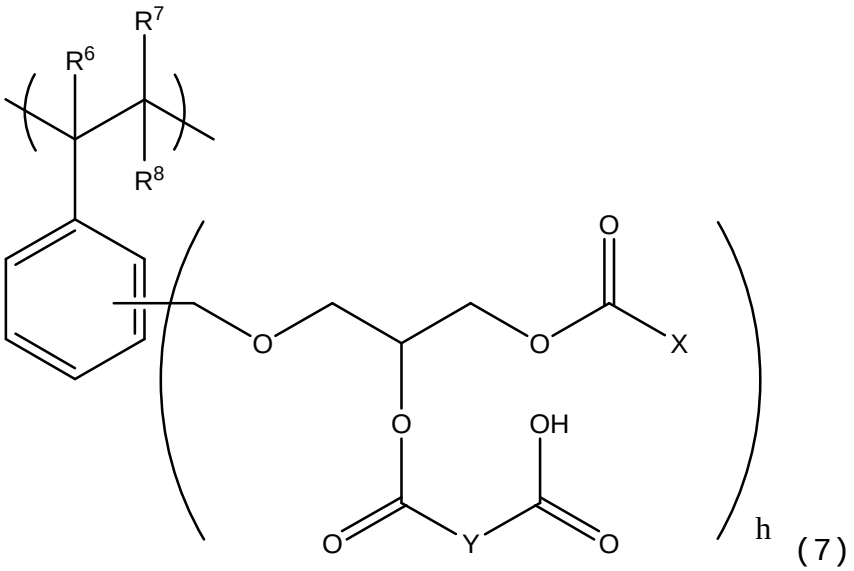


(6)

[0039]

where R^5 represents a hydrogen atom or a methyl group; and

[0040]



(7)

[0041]

where: R^6, R^7, and R^8 each independently represent a hydrogen atom or an alkyl group having 1 to 10 carbon atoms; X represents a monovalent organic group having an acryloyl group or a methacryloyl group, a vinyl group, or a 1-methylvinyl group; Y represents a divalent organic group; and h represents an integer of 1 to 5.

[0042]

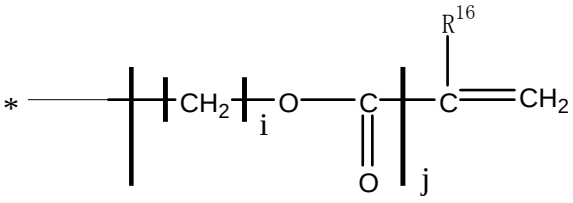
In the formula (7), R^6 represents preferably a hydrogen atom or a methyl group, or more preferably a hydrogen atom. R^7 and R^8 each represent preferably a hydrogen atom. h represents preferably 1.

[0043]

In the formula (7), a monovalent organic group

represented by X and having an acryloyl group or a methacryloyl group is preferably the group represented by the formula (X-1) or (X-2) below, and X in the formula (7) is preferably a vinyl group or a 1-methylvinyl group:

[0044]

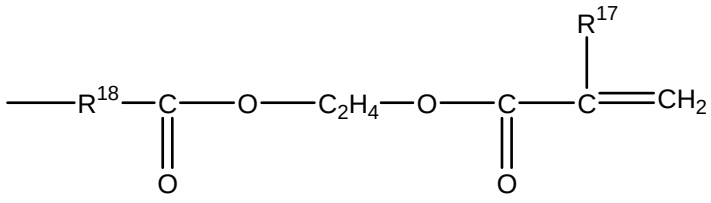


(X-1)

[0045]

where R^{16} represents a hydrogen atom or a methyl group, i represents an integer of 2 to 5, j represents an integer of 1 to 10, and "*" represents a bond; and

[0046]



(X-2)

[0047]

where: R^{17} represents a hydrogen atom or a methyl group; R^{18} represents a single bond, a methylene group, an alkylene group having 2 to 6 carbon atoms, a cyclohexane-1,2-diyl group, or a 1,2-phenylene group; and "*" represents a bond.

[0048]

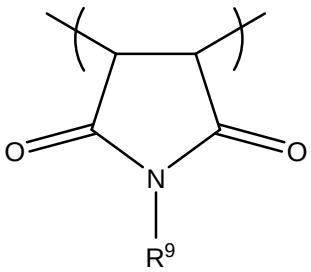
In the formula (7), Y represents preferably a methylene group, an alkylene group having 2 to 6 carbon atoms, an alkenylene group having 2 to 6 carbon atoms (provided that an

oxygen atom may be bonded in the midstream of those alkylene group and alkenylene group), a cyclohexanediyl group, a cyclohexenediyl group, or an arylene group having 6 to 12 carbon atoms (provided that the arylene group may have a carboxyl group or a anhydride group), or more preferably a methylene group, an ethylene group, a 1,3-propylene group, a 1,2-ethenylene group, a 1,2-propenylene group, a 1,3-propenylene group, a 2,3-propenylene group, a cyclohexane-1,2-diyl group, a 4-cyclohexene-1,2-diyl group, a 1,2-phenylene group, a biphenyl-2,2'-diyl group, or a divalent group represented by $-CH_2-O-CH_2-$.

[0049]

It is preferred that the alkali-soluble resin (B) contained in the radiation-sensitive composition of the present invention be a polymer having, in addition to the repeating unit represented by the formula (6) or the formula (7), at least one kind of repeating units selected from the group consisting of a repeating unit represented by the following formula (8) and a repeating unit represented by the following formula (9):

[0050]

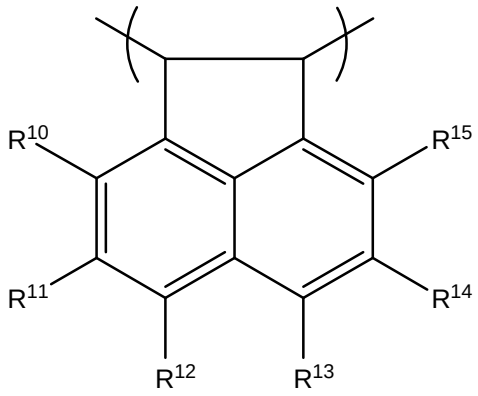


(8)

[0051]

where R^9 represents a linear, branched, or cyclic alkyl group having 1 to 12 carbon atoms or an aryl group having 6 to 12 carbon atoms; and

[0052]



(9)

[0053]

where R^{10} to R^{15} each independently represent a hydrogen atom, a halogen atom, a hydroxyl group, a hydroxymethyl group, or a carboxyl group.

[0054]

In the formula (8), examples of the linear, branched, or cyclic alkyl group having 1 to 12 carbon atoms and represented by R^9 include a methyl group, an ethyl group, an n-propyl group, an i-propyl group, an n-butyl group, an i-butyl group, a sec-butyl group, a t-butyl group, an n-pentyl group, an n-hexyl group, an n-heptyl group, an n-octyl group, an n-nonyl group, an n-decyl group, an n-undecyl group, an n-dodecyl group, a cyclopentyl group, and a cyclohexyl group.

[0055]

In addition, examples of the aryl group having 6 to 12 carbon atoms and represented by R^9 include a phenyl group, an o-tolyl group, an m-tolyl group, a p-tolyl group, a 1-naphthyl group, and a 2-naphthyl group.

[0056]

R^9 in the formula (8) represents preferably a cyclohexyl group or a phenyl group, or particularly preferably a phenyl group.

[0057]

Examples of the halogen atom represented by R^{10} to R^{15} in the formula (9) include a chlorine atom, a bromine atom, or an iodine atom, and a chlorine atom is preferred.

In the formula (9), it is preferred that R^{10} to R^{15} all represent a hydrogen atom or that R^{12} represent a chlorine atom, a hydroxyl group, or a hydroxymethyl group and all R^{10}, R^{11}, and R^{13} to R^{15} all represent a hydrogen atom. It is more preferred that R^{10} to R^{15} all represent a hydrogen atom.

[0058]

In a polymer (B1), the repeating unit represented by the formula (6) is preferably 1 to 40 wt% and more preferably 5 to 30 wt% with respect to the total repeating unit of the polymer (B1). Further, in a polymer (B2), the repeating unit represented by the formula (7) is preferably 5 to 80 wt% and more preferably 10 to 60 wt% with respect to the total repeating unit of the polymer (B2). In the alkali-soluble

resin (B), by setting the repeating unit represented by the formula (6) or the formula (7) to the above range, the development property of the radiation-sensitive composition containing the repeating unit becomes better and the suppression of residue generation at the time of development becomes more effective, which is preferred.

[0059]

The polymer (B1) and the polymer (B2) of the present invention each have the repeating unit represented by the formula (8) preferably in a range of 50 wt% or less and more preferably in a range of 5 to 40 wt% with respect to the total repeating unit of the polymer (B1) or the polymer (B2). Further, the polymer (B1) and the polymer (B2) each have the repeating unit represented by the formula (9) preferably in a range of 60 wt% or less and more preferably in a range of 5 to 40 wt% with respect to the total repeating unit of the polymer (B1) or the polymer (B2). Still further, the polymer (B1) and the polymer (B2) may each have both the repeating unit represented by the formula (8) and the repeating unit represented by the formula (9), and in this case, the total of the content proportions of the repeating units is preferably 80 wt% or less and more preferably 10 to 70 wt% with respect to the total repeating unit of the polymer (B1) or the polymer (B2). In this case, the individual content proportions of the repeating unit represented by the formula (8) and the

repeating unit represented by the formula (9) are preferably within the value ranges mentioned above.

[0060]

In the polymer (B1) and the polymer (B2), by setting the content proportions of the repeating unit represented by the formula (8) and the repeating unit represented by the formula (9) to the above ranges, an advantage may be obtained that the adhesion to the substrate is further improved, which is preferred.

[0061]

The weight average molecular weight (hereinafter may be referred to as Mw) in terms of polystyrene measured by gel permeation chromatography (GPC; tetrahydrofuran used as an elution solvent) in the alkali-soluble resin (B) of the present invention is preferably 1,000 to 45,000, and particularly preferably 3,000 to 20,000.

Further, the average molecular weight (hereinafter may be referred to as Mn) in terms of polystyrene measured by gel permeation chromatography (GPC; tetrahydrofuran used as an elution solvent) in the alkali-soluble resin (B) of the present invention is preferably 1,000 to 45,000, and particularly preferably 3,000 to 20,000.

In this case, when Mw is less than 1,000, a residual film rate or the like of a coating film to be obtained may be decreased, pattern form, heat resistance, or the like may be

impaired, or electrical characteristics may become worse, and on the other hand, when Mw exceeds 45,000, definition may be decreased, pattern form may be impaired, or dry foreign matter may easily occur at the time of coating by a slit nozzle method.

[0062]

The polymer (B1) may be produced by polymerizing, for example, in an appropriate solvent, a radical polymerizable compound formed by containing (meth)acrylic acid and in the presence of a radical polymerization initiator such as 2,2'-azobisisobutyronitrile, 2,2'-azobis(2,4-dimethylvaleronitrile), or 2,2'-azobis(4-methoxy-2,4-dimethylvaleronitrile).

[0063]

Further, the polymer (B1) may be purified by subjecting the radical polymerizable compound to the radical polymerization as described above, and then undergoing a reprecipitation method which uses two or more kinds of organic solvents having different polarities. That is, the polymer is purified by: pouring a solution in a good solvent after the polymerization into a large quantity (generally, 5 to 10 times the volume of the polymer solution) of precipitant (poor solvent), after the solution in the good solvent after the polymerization is subjected to filtration or centrifugal separation as required to thereby remove insoluble impurities; and reprecipitating the polymer. On this occasion, of the

impurities remaining in the polymer solution, the impurities which are soluble in the precipitant remain in the liquid phase and are separated from the purified polymer (B1).

Examples of the combinations of good solvents with precipitants used in the reprecipitation method include cyclohexanone with n-hexane, propylene glycol monoethyl ether with n-hexane, cyclohexanone with n-heptane, and propylene glycol monoethyl ether with n-heptane.

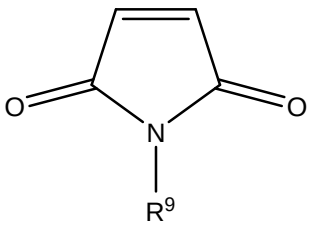
[0064]

Further, the polymer (B1) may be produced, for example, by subjecting the radical polymerizable compound to living radical polymerization in inactive solvents, generally at a reaction temperature of 0 to 150°C and more preferably 50 to 120°C, in the presence of the above-mentioned radical polymerization initiator and a molecular weight controlling agent which functions as iniferter such as pyrazole-1-dithiocarboxylic acid cyano(dimethyl) methyl ester, pyrazole-1-dithiocarboxylic acid benzyl ester, tetraethylthiuram disulfide, bis(pyrazole-1-ylthiocarbonyl)disulfide, bis(3-methyl-pyrazole-1-ylthiocarbonyl) disulfide, bis(4-methyl-pyrazole-1-ylthiocarbonyl) disulfide, bis(5-methyl-pyrazole-1-ylthiocarbonyl) disulfide, bis(3,4,5-trimethyl-pyrazole-1-ylthiocarbonyl) disulfide, bis(pyrrole-1-ylthiocarbonyl) disulfide, or bisthiobenzoyl disulfide.

[0065]

In the polymer (B1), as another radical polymerizable compound which is preferably copolymerized with (meth)acrylic acid, there may be exemplified: a compound represented by the following formula (8-1) (hereinafter may be referred to as "compound (b1)"); a compound represented by the following formula (9-1) (hereinafter may be referred to as "compound (b2)"); and a radical polymerizable compound other than (meth)acrylic acid, the compound (b1), and the compound (b2) (hereinafter referred to as "compound (b3)"). Further, in the polymer (B1), the polymer (B1) copolymerized with a radical polymerizable compound having a hydroxyl group such as 2-hydroxyethyl(meth)acrylate is reacted with an unsaturated isocyanate compound such as 2-(meth)acryloyloxyethyl isocyanate, for example, whereby a polymerizable unsaturated bond may be introduced to a side chain of the polymer.

[0066]

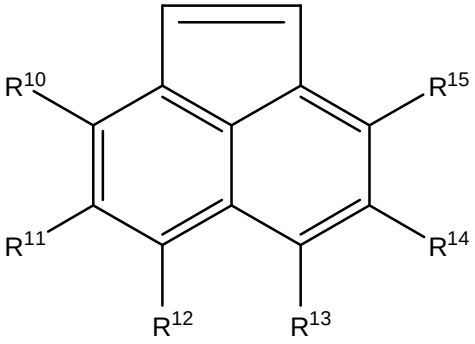


(8-1)

[0067]

In the formula, R^9 has the same meaning as R^9 in the formula (8).

[0068]



(9-1)

[0069]

In the formula, R^{10} to R^{15} each have the same meanings as R^{10} to R^{15} in the formula (9).

[0070]

The compound (b1) introduces a repeating unit represented by the formula (8) into the alkali-soluble resin (B). Specific examples of the compound (b1) include N-methyl maleimide, N-ethyl maleimide, N-n-propyl maleimide, N-i-propyl maleimide, N-n-butyl maleimide, N-t-butyl maleimide, N-n-hexyl maleimide, N-cyclopentyl maleimide, N-cyclohexyl maleimide, N-phenyl maleimide, and N-1-naphthyl maleimide. Of those compounds (b1), N-cyclphexyl maleimide and N-phenyl maleimide are preferred and N-phenyl maleimide is particularly preferred. In the polymer (B1), the compounds (b1) may be used alone or in a mixture of two or more.

[0071]

The compound (b2) introduces a repeating unit represented by the formula (9) into the alkali-soluble resin (B). Specific examples of the compound (b2) include acenaphthylene, 5-chloroacenaphthylene, 5-hydroxymethylacenaphthylene, and 5-

hydroxyacenaphthylene. Of those compounds (b2), acenaphthylene and 5-chloroacenaphthylene are preferred and acenaphthylene is particularly preferred. In the polymer (B1), the compounds (b2) may be used alone or in a mixture of two or more.

[0072]

Examples of the compound (b3) include:

unsaturated monocarboxylic acids such as crotonic acid, α-chloroacrylic acid, and cinnamic acid;

unsaturated dicarboxylic acids and anhydrides thereof such as maleic acid, maleic anhydride, fumaric acid, itaconic acid, itaconic anhydride, citraconic acid, citraconic anhydride, and mesaconic acid;

mono[(meth)acryloyloxyalkyl]esters of polycarboxylic acids having at least two carboxyl groups in the molecule such as mono[2-(meth)acryloyloxyethyl]succinate and mono[2-(meth)acryloyloxyethyl]phthalate;

mono(meth)acrylates of polymers having a carboxyl group and a hydroxyl group at both terminals such as ω-carboxy polycaprolactone mono(meth)acrylate;

unsaturated phenols such as o-vinylphenol, m-vinylphenol, p-vinylphenol, 2-methyl-4-vinylphenol, 3-methyl-4-vinylphenol, o-isopropenylphenol, m-isopropenylphenol, and p-isopropenylphenol;

unsaturated naphthols such as 2-vinyl-1-naphthol, 3-vinyl-1-naphthol, 1-vinyl-2-naphthol, 3-vinyl-2-naphthol, 2-

isopropenyl-1-naphthol, and 3-isopropenyl-1-naphthol;

[0073]

aromatic vinyl compounds such as styrene, α-methylstyrene, o-vinyltoluene, m-vinyltoluene, p-vinyltoluene, p-chlorostyrene, o-methoxystyrene, m-methoxystyrene, p-methoxystyrene, o-vinylbenzyl methylether, m-vinylbenzyl methylether, p-vinylbenzyl methylether, o-vinylbenzyl glycidyl ether, m-vinylbenzyl glycidyl ether, and p-vinylbenzyl glycidyl ether;

indenes such as indene and 1-methylindene;

[0074]

unsaturated carboxylates such as methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, i-propyl (meth)acrylate, n-butyl (meth)acrylate, i-butyl (meth)acrylate, sec-butyl (meth)acrylate, t-butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 3-hydroxybutyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, allyl (meth)acrylate, benzyl (meth)acrylate, cyclohexyl (meth)acrylate, phenyl (meth)acrylate, 2-methoxyethyl (meth)acrylate, 2-phenoxyethyl (meth)acrylate, methoxy diethylene glycol (meth)acrylate, methoxy triethylene glycol (meth)acrylate, methoxy propylene glycol (meth)acrylate, methoxy dipropylene glycol (meth)acrylate, isobornyl (meth)acrylate, tricyclo[5.2.1.$0^{2,6}$]decane-8-yl (meth)acrylate,

2-hydroxy-3-phenoxypropyl (meth)acrylate, glycerol mono(meth)acrylate, 4-hydroxyphenyl (meth)acrylate, and ethylene oxide-modified (meth)acrylate of p-qumylphenol;

[0075]

unsaturated aminoalkyl carboxylates such as 2-aminoethyl(meth)acrylate, 2-dimethylaminoethyl(meth)acrylate, 2-aminopropyl(meth)acrylate, 2-dimethylaminopropyl(meth)acrylate, 3-aminopropyl(meth)acrylate, and 3-dimethylaminopropyl(meth)acrylate;

unsaturated glycidyl carboxylates such as glycidyl (meth)acrylate;

vinyl cyanide compounds such as (meth)acrylonitrile, α-chloroacrylonitrile, and vinylidene cyanide;

unsaturated amides such as (meth)acrylamide, α-chloroacrylamide, and N-2-hydroxyethyl (meth)acrylamide;

vinyl carboxylates such as vinyl acetate, vinyl propionate, vinyl butyrate, and vinyl benzoate;

unsaturated ethers such as vinylmethyl ether, vinylethyl ether, and allyl glycidyl ether;

aliphatic conjugated dienes such as 1,3-butadiene, isoprene, and chloroprene; and

macromonomers having a mono(meth)acryloyl group at the terminal of a polymer molecular chain such as polystyrene, polymethyl (meth)acrylate, poly-n-butyl (meth)acrylate, and polysiloxane.

[0076]

In the polymer (B1), as the compound (b3), mono[(meth)acryloyloxyalkyl]esters of polycarboxylic acids having two or more valencies, mono(meth)acrylates of polymers having a carboxy group and a hydroxyl group at the both terminals, unsaturated phenols, aromatic vinyl compounds, unsaturated carboxylates, and macromonomers having mono(meth)acryloyl group at the terminal of a molecular chain are preferred, and mono[2-(meth)acryloyloxyethyl] succinate, ω-carboxypolycaprolactone mono(meth)acrylate, p-isopropenyl phenol, styrene, α-methyl styrene, methyl (meth)acrylate, n-butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, allyl (meth)acrylate, benzyl (meth)acrylate, phenyl (meth)acrylate, glycerol mono(meth)acrylate, 4-hydroxyphenyl (meth)acrylate, ethylene oxide-modified (meth)acrylate of p-qumylphenol, polystyrene macromonomer, and polymethyl methacrylate macromonomer are particularly preferred.

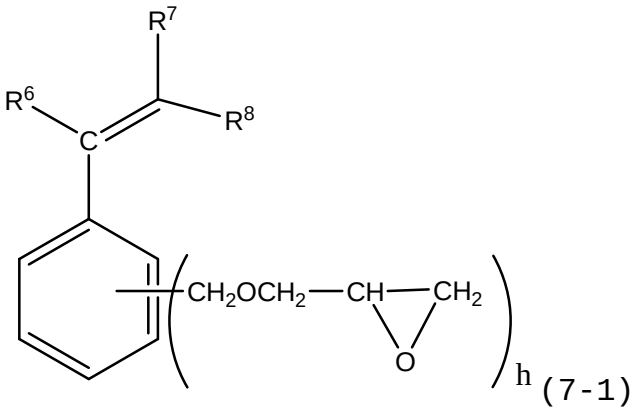
In the polymer (B1), the compound (b3) may be used alone or two or more kinds thereof may be used in mixture.

[0077]

Further, the polymer (B2) may be produced by: adding a compound represented by the following formula (7-2) (hereinafter referred to as "unsaturated monocarboxylic acid (X)") to a polymer (hereinafter may be referred to as "styrene

epoxy polymer") of a radical polymerizable compound formed by containing a compound represented by the following formula (7-1) (hereinafter may be referred to as "compound (b4)"); and then adding a compound represented by the following formula (7-3) (hereinafter referred to as "polybasic acid anhydride (y)") to the mixture.

[0078]

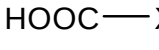


(7-1)

[0079]

In the formula, R^6, R^7, R^8, and h each have the same meanings as R^6, R^7, R^8, and h in the formula (7).

[0080]

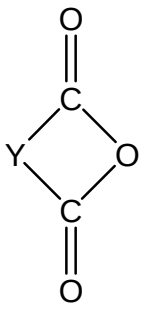


(7-2)

[0081]

In the formula, X has the same meaning as X in the formula (7).

[0082]



(7-3) [0083]

In the formula, Y has the same meaning as Y in the formula (7).

[0084]

Specific examples of the compound (b4) include o-vinylbenzyl glycidyl ether, m-vinylbenzyl glycidyl ether, p-vinylbenzyl glycidyl ether, α-methyl-o-vinylbenzyl glycidyl ether, α-methyl-m-vinylbenzyl glycidyl ether, α-methyl-p-vinylbenzyl glycidyl ether, 2,3-diglycidyloxymethylstyrene, 2,4-diglycidyloxymethylstyrene, 2,5-diglycidyloxymethylstyrene, 2,6-diglycidyloxymethylstyrene, 2,3,4-triglycidyloxymethylstyrene, 2,3,5-triglycidyloxymethylstyrene, 2,3,6-triglycidyloxymethylstyrene, 3,4,5-triglycidyloxymethylstyrene, and 2,4,6-triglycidyloxymethylstyrene. Of those compounds (b4), o-vinylbenzyl glycidyl ether, m-vinylbenzyl glycidyl ether, and p-vinylbenzyl glycidyl ether are preferred, and p-vinylbenzyl glycidyl ether is particularly preferred. In the polymer (B2), those compounds (b4) may be used alone or in a mixture of two or more.

[0085]

In the styrene epoxy polymer, as another radical polymerizable compound which is preferably copolymerized with the compound (b4), there may be exemplified the compound (b1), the compound (b2), and the compound (b3). In the styrene epoxy polymer, preferable examples of the compound (b1) and the compound (b2) include the same compounds as exemplified in the polymer (B1). In addition, as the compound (b3) in the styrene epoxy polymer, aromatic vinyl compounds, unsaturated carboxylates, and macromonomers each having a mono(meth)acryloyl group at the terminal of a polymer molecular chain are preferred. Particularly, styrene, α-methylstyrene, methyl (meth)acrylate, n-butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, allyl (meth)acrylate, benzyl (meth)acrylate, phenyl (meth)acrylate, glycerol mono(meth)acrylate, ethylene oxide-modified (meth)acrylate of p-qumylphenol, polystyrene macromonomer, and polymethyl methacrylate macromonomer are preferred.

In the styrene epoxy polymer, the compound (b1), the compound (b2), and the compound (b3) may each be used alone or in a mixture of two or more.

[0086]

The styrene epoxy polymer may be produced in the same manner as the polymer (B1), and Mw and Mn of the styrene epoxy polymer may be set appropriately in accordance with desired Mw

and Mn of the alkali-soluble resin (B).

[0087]

The unsaturated monocarboxylic acid (X) may be appropriately selected in accordance with a desired kind of X. As the preferred unsaturated monocarboxylic acid (X), acrylic acid, methacrylic acid, ω-carboxy-polycaprolactone monoacrylate, ω-carboxy-polycaprolactone monomethacrylate, 2-acryloyloxyethyl succinate, 2-methacryloyloxyethyl succinate are preferably exemplified. In the above ω-carboxy-polycaprolactone monoacrylate and ω-carboxy-polycaprolactone monomethacrylate, the number of the repeating units of polycaprolactone is preferably 1 to 10 and more preferably 2 to 5. Of those unsaturated monocarboxylic acids (X), acrylic acid or methacrylic acid is preferred because it is highly reactive, and acrylic acid is particularly preferred.

The unsaturated monocarboxylic acids (X) may be used alone or in a mixture of two or more.

[0088]

The addition reaction of the unsaturated monocarboxylic acid (X) to the styrene epoxy polymer may be performed in accordance with a known method. The amount of the unsaturated monocarboxylic acid (X) for use is, with respect to 1 equivalent of the epoxy group of the styrene epoxy polymer, preferably in a range of 0.7 to 1.3 equivalent and more preferably in a range of 0.9 to 1.2 equivalent.

[0089]

The polybasic acid anhydride (y) may be selected according to the desired kinds of Y in the formula (7). Examples of the preferred polybasic acid anhydride (y) include malonic acid anhydride, maleic acid anhydride, citraconic acid anhydride, succinic acid anhydride, glutaric acid anhydride, glutaconic acid anhydride, itaconic acid anhydride, diglycolic acid anhydride, phthalic acid anhydride, cyclohexane-1,2-dicarboxylic acid anhydride, 4-cyclohexene-1,2-dicarboxylic acid anhydride, and diphenic acid anhydride. Of those, succinic acid anhydride, glutaric acid anhydride, phthalic acid anhydride, or 4-cyclohexene-1,2-dicarboxylic acid anhydride are particularly preferred because they are rich in reactivity.

[0090]

The addition reaction of the polybasic acid anhydride (y) to the styrene epoxy polymer may be performed in accordance with a known method. The addition amount of the polybasic acid anhydride (y) is, with respect to 1 equivalent of the epoxy group of the styrene epoxy polymer, preferably in a range of 0.2 to 1.0 equivalent and more preferably in a range of 0.4 to 0.9 equivalent.

[0091]

In the present invention, the polymers (B1) and the polymers (B2) may each be used alone or in a mixture of two or

more. Further, as the alkali-soluble resin, there may be used, for example, a copolymer of (meth)acrylic acid and the compound (b3), together with the polymer (B1) and/or the polymer (B2).

In the present invention, the content of the alkali-soluble resin is generally preferably 10 to 1,000 parts by weight and particularly preferably 20 to 500 parts by weight with respect to 100 parts by weight of the colorant (A). In this case, when the content of the alkali-soluble resin is less than 10 parts by weight, for example, alkali development property may decrease, and film residue or scum may occur on the unexposed part of the substrate or on the light-shielding layer. On the other hand, when the content of the alkali-soluble resin exceeds 1,000 parts by weight, it may become difficult to achieve a target color density as a thin film, because the concentration of the colorant is relatively decreased.

[0092]

-Monomer having two or more radical polymerizable unsaturated bonds (C)-

Examples of the monomer having two or more radical polymerizable unsaturated bonds (C) in the present invention is a monomer having two or more polymerizable unsaturated bonds (hereinafter may be referred to as "polyfunctional monomer") include:

di(meth)acrylates of alkylene glycols such as ethylene glycol and propylene glycol;

di(meth)acrylates of polyalkylene glycols such as polyethylene glycol and polypropylene glycol;

poly(meth)acrylates of a polyol with a valency of 3 or more such as glycerine, trimethylolpropane, pentaerythritol, and dipentaerythritol, or dicarboxylate-modified products thereof;

oligo(meth)acrylates such as polyester, an epoxy resin, a urethane resin, an alkyd resin, a silicone resin, and a spirane resin;

di(meth)acrylates of both-terminal hydroxylated polymers such as both-terminal hydroxypoly-1,3-butadiene, both-terminal hydroxypolyisoprene, and both-terminal hydroxypolycaprolactone; and

tris[2-(meth)acryloyloxyethyl]phosphate and ethylene oxide-modified triacrylate isocyanylate.

[0093]

Of those polyfunctional monomers, preferred are poly(meth)acrylate of a polyol having a valency of 3 or more, and a dicarboxylic acid modified product thereof, specifically, trimethylolpropane triacrylate, trimethylolpropane trimethacrylate, pentaerythritol triacrylate, pentaerythritol trimethacrylate, pentaerythritol tetraacrylate, pentaerythritol tetramethacrylate, dipentaerythritol

pentaacrylate, dipentaerythritol pentamethacrylate, dipentaerythritol hexaacrylate, dipentaerythritol hexamethacrylate, a monoesterified product of pentaerythritol triacrylate and succinic acid, a monoesterified product of pentaerythritol trimethacrylate and succinic acid, a monoesterified product of dipentaerythritol pentaacrylate and succinic acid, a monoesterified product of dipentaerythritol pentamethacrylate and succinic acid, and the like. Particularly preferred are trimethylol propanetriacrylate, pentaerythritol triacrylate, dipentaerythritol pentaacrylate, dipentaerythritol hexaacrylate, a monoesterified product of pentaerythritol triacrylate and succinic acid, and a monoesterified product of dipentaerythritol pentaacrylate and succinic acid, because they are excellent in strength and surface smoothness of a coloring layer and hardly generate scum, film residue, or the like on the unexposed part of the substrate and on the light-shielding layer.

The polyfunctional monomers may be used alone or in a mixture of two or more.

[0094]

The content of the polyfunctional monomer (C) in the present invention is generally preferably 5 to 500 parts by weight and particularly preferably 20 to 300 parts by weight with respect to 100 parts by weight of the alkali-soluble resin (B). In this case, when the content of the

polyfunctional monomer is less than 5 parts by weight, strength and surface smoothness of the coloring layer tend to be decreased, and on the other hand, when the content of the polyfunctional monomer exceeds 500 parts by weight, for example, alkali development property tends to decrease, and scum, film residue, or the like tends to occur on the unexposed part of the substrate or on the light-shielding layer.

[0095]

Further, in the present invention, a part of the polyfunctional monomer may be replaced by a monomer having one radical polymerizable unsaturated bond (hereinafter may be referred to as "monofunctional monomer").

Examples of the monofunctional monomers include mono[(meth)acryloyloxyalkyl]esters of polycarboxylic acids having at least two carboxyl groups in the molecule such as mono[2-(meth)acryloyloxyethyl]succinate and mono[2-(meth)acryloyloxyethyl]phthalate; and mono(meth)acrylates of polymers having a carboxyl group and a hydroxyl group at both terminals such as ω-carboxy polycaprolactone mono(meth)acrylate; N-(meth)acryloylmorpholine; N-vinyl-pyrrolidone; N-vinyl-ε-caprolactam; and as commercially available products, M-5600 (manufactured by Toagosei Co., Ltd.).

Those monofunctional monomers may be used alone or in a

mixture of two or more. The content proportion of the monofunctional monomer is generally 90 wt% or less and preferably 50 wt% or less with respect to the total amount of the polyfunctional monomer and the monofunctional monomer. In this case, when the content proportion of the monofunctional monomer to be used exceeds 90 wt%, strength and surface smoothness of the coloring layer to be obtained may become insufficient.

[0096]

-Radiation-sensitive radical generating agent (D)-

The radiation-sensitive radical generating agent (D) to be used in the present invention refers to a compound which generates an active radicals that may initiate polymerization of the polyfunctional monomer and the monofunctional monomer to be used in some cases by exposure of radiation such as visible light ray, ultraviolet ray, far ultraviolet ray, electron ray, or X-ray.

Examples of the radiation-sensitive radical generating agent include acetophenone-based compounds, biimidazole-based compounds, triazine-based compounds, O-acyloxime-based compounds, benzoin-based compounds, and α-diketone-based compounds.

[0097]

In the present invention, the radiation-sensitive radical generating agents may be used alone or in a mixture of two or

more, and as the radiation-sensitive radical generating agent in the present invention, at least one kind selected from the group consisting of an acetophenone-based compound, a biimidazole-based compound, a triazine-based compound, and an O-acryloxime-based compound is preferred.

[0098]

In the present invention, the content of the radiation-sensitive radical generating agent (D) is generally 0.01 to 120 parts by weight and preferably 1 to 100 parts by weight with respect to 100 parts by weight of the polyfunctional monomer (C). In this case, when the content of the radiation-sensitive radical generating agent is less than 0.01 part by weight, curing by exposure may become insufficient, with the result that it may become difficult to obtain a color filter in which a coloring layer pattern is formed in accordance with a predetermined arrangement, and on the other hand, when the content of the radiation-sensitive radical generating agent exceeds 120 parts by weight, the formed coloring layer tends to fall off easily from the substrate at the time of development.

[0099]

Of the preferable radiation-sensitive radical generating agents in the present invention, specific examples of the acetophenone-based compounds include 2-hydroxy-2-methyl-1-phenylpropane-1-one, 2-methyl-1-[4-(methylthio)phenyl]-2-

morpholinopropane-1-one, 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one, 2-(4-methylbenzyl)-2-(dimethylamino)-1-(4-morpholinophenyl)butane-1-one, 1-hydroxy cyclohexyl/phenyl ketone, 2,2-dimethoxy-1,2-diphenylethane-1-one, and 1,2-octanedione.

Of those acetophenone-based compounds, 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropane-1-one, 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one, 2-(4-methylbenzyl)-2-(dimethylamino)-1-(4-morpholinophenyl)butane-1-one, and 1,2-octanedione are particularly preferable.

The above acetophenone-based compounds may be used alone or in a mixture of two or more.

[0100]

In the present invention, in the case where the acetophenone-based compound is used as the radiation-sensitive radical generating agent, the content of the acetophenone-based compound is generally preferably 0.01 to 80 parts by weight, particularly preferably 1 to 70 parts by weight, and still more preferably 1 to 60 parts by weight with respect to 100 parts by weight of the polyfunctional monomer (C). In this case, when the content of the acetophenone-based compound is less than 0.01 part by weight, curing by exposure may become insufficient, with the result that it may become difficult to obtain a color filter in which a coloring layer pattern is formed in accordance with a predetermined arrangement, and on

the other hand, when the content of the acetophenone-based compound exceeds 80 parts by weight, the formed coloring layer tends to fall off easily from the substrate at the time of development.

[0101]

In addition, specific examples of the biimidazole-based compound include 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetrakis(4-ethoxycarbonylphenyl)-1,2'-biimidazole, 2,2'-bis(2-bromophenyl)-4,4',5,5'-tetrakis(4-ethoxycarbonylphenyl)-1,2'-biimidazole, 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, 2,2'-bis(2,4-dichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, 2,2'-bis(2,4,6-trichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, 2,2'-bis(2-bromophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, 2,2'-bis(2,4-dibromophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, and 2,2'-bis(2,4,6-tribromophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole.

[0102]

Of those biimidazole-based compounds, 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, 2,2'-bis(2,4-dichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole, and 2,2'-bis(2,4,6-trichlolophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole are preferred, and 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole is particularly preferred.

Those biimidazole-based compounds have excellent solubility to a solvent and do not generate foreign matters such as undissolved matter and precipitate. In addition, the biimidazole-based compounds have high sensitivity, and hence sufficiently allowing a curing reaction to proceed with exposure of a small amount of energy, and the curing reaction does not proceed at an unexposed part. Therefore, a coating film after exposure is clearly divided into a cured part which is insoluble to a developer and an uncured part which has high solubility to the developer. Thus, a high-definition color filter may be formed, in which coloring layer patterns having no undercut are formed in accordance with a predetermined arrangement.

The biimidazole-based compounds may be used alone or in a mixture of two or more.

[0103]

In the present invention, in the case where the biimidazole-based compound is used as the radiation-sensitive radical generating agent, the content of the biimidazole-based compound is generally preferably 0.01 to 40 parts by weight, particularly preferably 1 to 30 parts by weight, and still more preferably 1 to 20 parts by weight with respect to 100 parts by weight of the total of the polyfunctional monomers (C). In this case, when the content of the biimidazole-based compound is less than 0.01 part by weight, curing by exposure

may become insufficient, with the result that it may become difficult to obtain a color filter in which a coloring layer pattern is formed in accordance with a predetermined arrangement, and on the other hand, when the content of the biimidazole-based compound exceeds 40 parts by weight, the formed coloring layer tends to fall off easily from the substrate at the time of development.

[0104]

In the present invention, in the case where the biimidazole-based compounds are used as the radiation-sensitive radical generating agents, the following hydrogen donor is preferably used in combination therewith in terms of further improving sensitivity.

The "hydrogen donor" refers to a compound which may donate a hydrogen atom to a radical that is generated from the biimidazole-based compounds by exposure.

Mercaptan-based compounds and amine-based compounds defined below are preferred as the hydrogen donor in the present invention.

[0105]

The mercaptan-based compound is a compound (hereinafter referred to as "mercaptan-based hydrogen donor") which has a benzene ring or a heterocyclic ring as a mother nucleus, and has 1 or more, preferably 1 to 3, more preferably 1 or 2 mercapto groups which are each directly bonded to the mother

nucleus.

The amine-based compound is a compound (hereinafter referred to as "amine-based hydrogen donor") which has a benzene ring or a heterocyclic ring as a mother nucleus, and has 1 or more, preferably 1 to 3, or more preferably 1 or 2 amino groups which are each directly bonded to the mother nucleus.

Note that those hydrogen donors may have both the mercapto group and the amino group at the same time.

[0106]

Hereinafter, the hydrogen donor is described more specifically.

The mercaptan-based hydrogen donor may have one or more benzene rings or one or more heterocyclic rings, and may have both the benzene ring and the heterocyclic ring. When two or more rings are contained in the mercaptan-based hydrogen donor, the rings may or may not form a fused ring.

Further, when the mercaptan-based hydrogen donor has two or more mercapto groups: as long as at least one free mercapto group remains, one or more of the other mercapto groups may be substituted with an alkyl group, an aralkyl group, or an aryl group; and as long as at least one free mercapto group remains, the mercaptan-based hydrogen donor may have a structural unit in which two sulfur atoms are bonded to each other via a divalent organic group such as an alkylene group or a

structural unit in which two sulfur atoms are bonded to each other in the form of a disulfide bond.

Further, any moiety other than the mercapto group in the mercaptan-based hydrogen donor may be substituted with groups such as a carboxyl group, an alkoxycarbonyl group, a substituted alkoxycarbonyl group, a phenoxycarbonyl group, a substituted phenoxycarbonyl group, or a nitrile group.

[0107]

Specific examples of the mercaptan-based hydrogen donors include 2-mercaptobenzothiazole, 2-mercaptobenzooxazole, 2-mercaptobenzoimidazole, 2,5-dimercapto-1,3,4-thiadiazole, and 2-mercapto-2,5-dimethylaminopyridine.

Of those mercaptan-based hydrogen donors, 2-mercaptobenzothiazole and 2-mercaptobenzooxazole are preferable, and 2-mercaptobenzothiazole is particularly preferable.

[0108]

The amine-based hydrogen donor may have one or more benzene rings or one or more heterocyclic rings, and may have both the benzene ring and the heterocyclic ring. When two or more rings are contained in the amine-based hydrogen donor, the rings may or may not form a fused ring.

Further, in the amine-based hydrogen donor: one or more animo groups may be substituted with an alkyl group or a substituted alkyl group; and any moiety other than the amino

group may be substituted with groups such as a carboxyl group, an alkoxycarbonyl group, a substituted alkoxycarbonyl group, a phenoxycarbonyl group, a substituted phenoxycarbonyl group, or a nitrile group.

[0109]

Specific examples of the amine-based hydrogen donor include 4,4'-bis(dimethylamino)benzophenone, 4,4'-bis(diethylamino)benzophenone, 4-diethylaminoacetophenone, 4-dimethylaminopropiophenone, ethyl-4-dimethylaminobenzoate, 4-dimethylaminobezoate, and 4-dimethylaminobenzonitrile.

Of those amine-based hydrogen donors, 4,4'-bis(dimethylamino)benzophenone and 4,4'-bis(diethylamino)benzophenone are preferred, and 4,4'-bis(diethylamino)benzophenone is particularly preferred.

Note that even in the case where the radical generating agent is other than the biimidazole-based compounds, the amine-based hydrogen donors each have a function as a sensitizer.

[0110]

In the present invention, the hydrogen donors may be used alone or in a mixture of two or more, and it is preferred to use one or more kinds of the mercaptan-based hydrogen donors and one or more kinds of the amine-based hydrogen donors in combination, in terms of preventing the formed coloring layer from being fallen off from the substrate at the time of

development and of the coloring layer having high strength and sensitivity.

Specific examples of the combination of the mercaptane-based hydrogen donor and the amine-based hydrogen donor include 2-mercaptobenzothiazole/4,4'-bis(dimethylamino)benzophenone, 2-mercaptobenzothiazole/4,4'-bis(diethylamino)benzophenone, 2-mercaptobenzooxazole/4,4'-bis(dimethylamino)benzophenone, and 2-mercaptobenzooxazole/4,4'-bis(diethylamino)benzophenone. Examples of the more preferred combination include 2-mercaptobenzothiazole/4,4'-bis(diethylamino)benzophenone and 2-mercaptobenzooxazole/4,4'-bis(diethylamino)benzophenone. Examples of the particularly preferred combination include 2-mercaptobenzothiazole/4,4'-bis(diethylamino)benzophenone.

Further, the weight ratio of the mercaptan-based hydrogen donor to the amine-based hydrogen donor obtained when combining the mercaptan-based hydrogen donor and the amine-based hydrogen donor is generally 1:1 to 1:4, and preferably 1:1 to 1:3.

[0111]

In the present invention, when a hydrogen donor is used in combination with the biimidazole-based compound, the content of the hydrogen donor is preferably 0.01 to 40 parts by weight, more preferably 1 to 30 parts by weight, and particularly preferably 1 to 20 parts by weight with respect

to 100 parts by weight of the total of the polyfunctional monomers (C). In this case, when the content of the hydrogen donor is less than 0.01 part by weight, an effect for improving sensitivity tends to decrease, and on the other hand, when the content of the hydrogen donor exceeds 40 parts by weight, the formed coloring layer tends to fall off easily from the substrate at the time of development.

[0112]

Note that in the case where the amine-based hydrogen donors are used in combination with the radiation-sensitive radical generating agent other than the biimidazole-based compounds, such as the acetophenone-based compounds, the amine-based hydrogen donors may function as a sensitizer. When the amine-based hydrogen donors are used as a sensitizer, the content thereof is generally preferably 300 parts by weight or less, particularly preferably 200 parts by weight or less, and still more preferably 100 parts by weight or less with respect to 100 parts by weight of the radiation-sensitive radical generating agent other than the biimidazole-based compounds. It is desirable that the lower limit of the content be preferably 2 parts by weight and more preferably 5 parts by weight, because when the content is too small, it becomes difficult to obtain a sufficient effect.

[0113]

In addition, specific examples of the triazine-based

compound include triazine-based compounds having a halomethyl group such as 2,4,6-tris(trichloromethyl)-s-triazine, 2-methyl-4,6-bis(trichloromethyl)-s-triazine, 2-[2-(5-methylfuran-2-yl)ethenyl]-4,6-bis(trichloromethyl)-s-triazine, 2-[2-(furan-2-yl)ethenyl]-4,6-bis(trichloromethyl)-s-triazine, 2-[2-(4-diethylamino-2-methylphenyl)ethenyl]-4,6-bis(trichloromethyl)-s-triazine, 2-[2-(3,4-dimethoxyphenyl)ethenyl]-4,6-bis(trichloromethyl)-s-triazine, 2-(4-methoxyphenyl)-4,6-bis(trichloromethyl)-s-triazine, 2-(4-ethoxystyryl)-4,6-bis(trichloromethyl)-s-triazine, and 2-(4-n-butoxyphenyl)-4,6-bis(trichloromethyl)-s-triazine.

[0114]

Of those triazine-based compounds, 2-[2-(3,4-dimethoxyphenyl)ethenyl]-4,6-bis(trichloromethyl)-s-triazine is particularly preferable.

The triazine-based compounds may be used alone or in a mixture of two or more.

[0115]

In the present invention, in the case where the triazine-based compound is used as the radiation-sensitive radical generating agent, the content of the triazine-based compound is preferably 0.01 to 40 parts by weight, more preferably 1 to 30 parts by weight, and particularly preferably 1 to 20 parts by weight with respect to 100 parts by weight of the polyfunctional monomer (C). In this case, when the content of

the triazine-based compound is less than 0.01 part by weight, curing by exposure may become insufficient, with the result that it may become difficult to obtain a color filter in which a coloring layer pattern is formed in accordance with a predetermined arrangement, and on the other hand, when the content of the triazine-based compound exceeds 40 parts by weight, the formed coloring layer tends to fall off easily from the substrate at the time of development.

[0116]

Further, specific examples of the O-acyloxime-based compounds include 1,2-octanedion-1-[4-(phenylthio)phenyl]-2-(O-benzoyloxime); 1-[9-ethyl-6-benzoyl-9H-carbazol-3-yl]-nonane-1,2-nonane-2-oxime-O-benzoate; 1-[9-ethyl-6-benzoyl-9H-carbazol-3-yl]-nonane-1,2-nonane-2-oxime-O-acetate; 1-[9-ethyl-6-benzoyl-9H-carbazol-3-yl]-pentane-1,2-pentane-2-oxime-O-acetate; 1-[9-ethyl-6-benzoyl-9H-carbazol-3-yl]-octane-1-one oxime-O-acetate; 1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-ethane-1-one oxime-O-benzoate; 1-[9-ethyl-6-(1,3,5-trimethylbenzoyl)-9H-carbazol-3-yl]ethane-1-one oxime-O-benzoate; 1-[9-butyl-6-(2-ethylbenzoyl)-9H-carbazol-3-yl]-ethane-1-one oxime-O-benzoate; ethanone, 1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-, 1-(O-acetyloxime); and ethanone, 1-[9-ethyl-6-[2-methyl-4-(2,2-dimethyl-1,3-dioxysolanyl)methoxybenzoyl]-9H-carbazol-3-yl]-, 1-(O-acetyloxime).

[0117]

Of those O-acyloxime-based compounds, 1,2-octanedion-1-[4-(phenylthio)phenyl]-2-(O-benzoyloxime); ethanone, 1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-, 1-(O-acetyloxime); and ethanone, 1-[9-ethyl-6-[2-methyl-4-(2,2-dimethyl-1,3-dioxysolanyl)methoxybenzoyl]-9H-carbazol-3-yl]-, 1-(O-acetyloxime) are preferable.

The O-acyloxime-based compounds may be used alone or in a mixture of two or more.

[0118]

In the present invention, in the case where the O-acyloxime-based compound is used as the radiation-sensitive radical generating agent, the content of the O-acyloxime-based compound is preferably 0.01 to 80 parts by weight, more preferably 1 to 60 parts by weight, and particularly preferably 1 to 50 parts by weight with respect to 100 parts by weight of the polyfunctional monomer (C). In this case, when the content of the O-acyloxime-based compound is less than 0.01 part by weight, curing by exposure may become insufficient, with the result that it may become difficult to obtain a color filter in which a coloring layer pattern is formed in accordance with a predetermined arrangement, and on the other hand, when the content of the O-acyloxime-based compound exceeds 80 parts by weight, the formed coloring layer tends to fall off easily from the substrate at the time of

development.

[0119]

-Component (E)-

The component (E) of the present invention is at least one kind of compound selected from the group consisting of compounds represented by the formulae (1) to (5), a phenolic compound having a flavan structure, a phenolic compound having a spirobiindane structure, and a phenolic compound having a spirobiindene structure. By containing those components, chipping, peeling, or undercut in the pattern at the time of development does not occur, and the line width of the pattern may be prevented from becoming thicker than the designed size of a photomask in proximity exposure.

[0120]

In the compound represented by the formula (1), the group A in the formula preferably represents a -CO- group, a methylene group, or an isopropylidene group. Further, R^1's each preferably represent a hydrogen atom, an alkyl group having 4 or less carbon atoms, or an alkoxy group having 4 or less carbon atoms.

Specific examples of the compound represented by the formula (1) include:

(polyhydroxy)benzophenones such as 2,3,4-trihydroxybenzophenone, 2,4,6-trihydroxybenzophenone, 2,2',4,4'-tetrahydroxybenzophenone, 2,3,4,3'-

tetrahydroxybenzophenone, 2,3,4,4'-tetrahydroxbenzophenone, 2,3,4,2'-tetrahydroxy-4'-methylbenzophenone, 2,3,4,4'-tetrahydroxy-3'-methoxybenzophenone, 2,3,4,2',6'-pentahydroxybenzophenone, 2,4,6,3',4',5'-hexahydroxybenzophenone, and 3,4,5,3',4',5'-hexahydroxybenzophenone;

bis(hydroxyphenyl)alkanes such as bis(p-hydroxyphenyl)methane; and

bis(polyhydroxyphenyl)alkanes such as bis(2,4-dihydroxphenyl)methane, bis(2,3,4-trihydroxyphenyl)methane, and 2,2-bis(2,3,4-trihydroxyphenyl)propane.

[0121]

In the compound represented by the formula (2), R^1's in the formula each preferably represent a hydrogen atom or an alkyl group having 4 or less carbon atoms, and R^4 in the formula preferably represents a hydrogen atom or an alkyl group having 6 or less carbon atoms.

Specific examples of the compound represented by the formula (2) include

tri(p-hydroxyphenyl)methane, 1,1,1-tri(p-hydroxyphenyl)ethane, bis(2,5-dimethyl-4-hydroxyphenyl)-2-hydroxyphenyl methane, and 2-[bis{(5-isopropyl-4-hydroxy-2-methyl)phenyl}methyl]phenol.

[0122]

In the compound represented by the formula (3), the group

A in the formula preferably represents a methylene group. R^1's in the formula each preferably represent a hydrogen atom or an alkyl group having 4 or less carbon atoms, and R^4's in the formula each preferably represent a hydrogen atom or an alkyl group having 6 or less carbon atoms.

A specific example of the compound represented by the formula (3) includes 1,1,3-tris(2,5-dimethyl-4-hydroxyphenyl)-3-phenylpropane.

[0123]

In the compound represented by the formula (4), R^1's in the formula each preferably represent a hydrogen atom, and R^2, R^3, and R^4 in the formula each preferably represent a hydrogen atom or an alkyl group having 6 or less carbon atoms.

A specific example of the compound represented by the formula (4) includes 4,4'-[1-[4-[1-[4-hydroxyphenyl]-1-methylethyl]phenyl]ethylidene]bisphenol.

[0124]

In the compound represented by the formula (5), R^1's in the formula each preferably represent a hydrogen atom, and R^2's and R^3's in the formula each preferably represent a hydrogen atom or an alkyl group having 6 or less carbon atoms.

Specific examples of the compound represented by the formula (5) include

4,6-bis{1-(4-hydroxyphenyl)-1-methylethyl}-1,3-dihydroxybenzene and 1-[1-(3-{1-(4-hydroxyphenyl)-1-

methylethyl}-4,6-dihydroxyphenyl)-1-methylethyl]-3-(1-(3-{1-(4-hydroxyphenyl)-1-methylethyl}-4,6-dihydroxyphenyl)-1-methylethyl)benzene.

[0125]

Specific examples of the phenolic compound having a fravan structure include

2-methyl-2-(2,4-dihydroxyphenyl)-4-(4-hydroxyphenyl)-7-hydroxychroman, 2,4,4-trimethyl-7,2',4'-trihydroxyfuravane.

Specific examples of the phenolic compound having a spirobiindane structure include 3,3,3',3'-tetramethyl-1,1'-spirobiindane-5,6,7,5',6',7'-hexanol.

Specific examples of the phenolic compound having a spirobiindene structure include 3,3'-dimethyl-1,1'-spirobiindene-5,6,7,5',6',7'-hexanol.

[0126]

Of those compounds, (polyhydroxy)benzophenones, the compound represented by the formula (4), and the phenolic compound having a fravan structure are preferred. 2,3,4-trihydroxybenzophenone, 2,3,4,4'-tetrahydroxybenzophenone, 2,3,4,2'6'-pentahydroxybenzophenone, 4,4'-[1-[4-[1-[4-hydroxyphenyl]-1-methylethyl]phenyl]ethylidene]bisphenol, and 2-methyl-2-(2,4-dihydroxyphenyl)-4-(4-hydroxyphenyl)-7-hydroxychroman are particularly preferred.

[0127]

In the present invention, the content of the component

(E) is preferably 0.1 to 10 parts by weight, more preferably 1 to 5 parts by weight, and particularly preferably 1 to 3 parts by weight with respect to 100 parts by weight of the alkali-soluble resin (B). In this case, when the content of the component (E) is less than 0.1 part by weight, a desired effect may not be obtained. On the other hand, when the content exceeds 10 parts by weight, the formed pattern tends to fall off easily from the substrate at the time of development.

[0128]

-Additive-

The radiation-sensitive composition of the present invention contains the above components (A) to (E) and may also contain other additives as required.

Here, examples of the other additives include: fillers such as glass and alumina; polymer compounds such as polyvinyl alcohol and poly(fluoroalkylacrylate); surfactants such as nonionic surfactants, cationic surfactants, and anionic surfactants; adhesion promoting agents such as vinyltrimethoxy silane, vinyltriethoxy silane, vinyltris(2-methoxyethoxy)silane, N-(2-aminoethyl)-3-aminopropylmethyldimethoxy silane, N-(2-aminoethyl)-3-aminopropyltrimethoxy silane, 3-aminopropyltriethoxy silane, 3-glycidoxypropyltrimethoxy silane, 3-glycidoxypropylmethyldimethoxy silane, 2-(3,4-

epoxycylohexyl)ethyltrimethoxy silane, 3-chloropropylmethyldimethoxy silane, 3-chloropropyltrimethoxy silane, 3-methacryloyloxypropyltrimethoxy silane, and 3-mercaptopropyltrimethoxy silane; antioxidants such as 2,2-thiobis(4-methyl-6-t-butylphenol) and 2,6-di-t-butylphenol; UV absorbers such as 2-(3-t-butyl-5-methyl-2-hydroxyphenyl)-5-chlorobenzotriazole, and alkoxybenzophenones; aggregation inhibitors such as sodium polacrylate; and alkali solubility improvers such as malonic acid, adipic acid, itaconic acid, citraconic acid, fumaric acid, and mesaconic acid.

[0129]

Solvent

The radiation-sensitive composition for forming a coloring layer of the present invention contains the above components (A) to (E) as essential components, and contains the above additive component as required. The radiation-sensitive composition is generally prepared as a liquid composition by compounding a solvent.

The solvent may be appropriately selected and used as long as the solvent disperses or dissolves the components (A) to (E) and the additive component which compose the radiation-sensitive composition, does not react with those components, and has appropriate volatility.

[0130]

Examples of the solvent include:

(poly)alkylene glycol monoalkyl ethers such as ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol mono-n-propyl ether, ethylene glycol mono-n-butyl ether, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, diethylene glycol mono-n-propyl ether, diethylene glycol mono-n-butyl ether, triethylene glycol monomethyl ether, triethylene glycol monoethyl ether, propylene glycol monomethyl ether, propylene glycol monoethyl ether, propylene glycol mono-n-propyl ether, propylene glycol mono-n-butyl ether, dipropylene glycol monomethyl ether, dipropylene glycol monoethyl ether, dipropylene glycol mono-n-propyl ether, dipropylene glycol mono-n-butyl ether, tripropylene glycol monomethyl ether, and tripropylene glycol monoethyl ether;

[0131]

(poly)alkylene glycol monoalkyl ether acetates such as ethylene glycol monomethyl ether acetate, ethylene glycol monoethyl ether acetate, diethylene glycol monomethyl ether acetate, diethylene glycol monoethyl ether acetate, propylene glycol monomethyl ether acetate, propylene glycol monoethyl ether acetate, and 3-methoxybutyl acetate;

other ethers such as diethylene glycol dimethyl ether, diethylene glycol methyl ethyl ether, diethylene glycol diethyl ether, and tetrahydrofuran;

ketones such as methyl ethyl ketone, cyclohexanone, 2-

heptanone, and 3-heptanone;

[0132]

lactic acid alkyl esters such as methyl lactate and ethyl lactate;

other esters such as ethyl 2-hydroxy-2-methyl-propionate, methyl 3-methoxy-propionate, ethyl 3-methoxy-propionate, methyl 3-ethoxy-propionate, ethyl 3-ethoxy-propionate, ethyl ethoxy acetate, ethyl hydroxy acetate, methyl 2-hydroxy-3-methyl butanoate, 3-methyl-3-methoxybutyl acetate, 3-methyl-3-methoxybutyl propionate, ethyl acetate, n-propyl acetate, i-propyl acetate, n-butyl acetate, i-butyl acetate, n-amyl formate, i-amyl acetate, n-butyl propionate, ethyl butyrate, n-propyl butyrate, i-propyl butyrate, n-butyl butyrate, methyl pyruvate, ethyl pyruvate, n-propyl pyruvate, methyl acetoacetate, ethyl acetoacetate, and ethyl 2-oxobutanoate;

aromatic hydrocarbons such as toluene and xylene; and

amides or lactams such as N,N-dimethyl formamide, N,N-dimethyl acetoamide, and N-methylpyrrolidone.

[0133]

Of those solvents, from the viewpoints of solubility, pigment dispersability, and coating property, preferred are propylene glycol monomethyl ether, ethylene glycol monomethyl ether acetate, propylene glycol monomethyl ether acetate, propylene glycol monoethyl ether acetate, 3-methoxybutyl acetate, diethylene glycol dimethyl ether, diethylene glycol

methyl ethyl ether, cyclohexanone, 2-heptanone, 3-heptanone, ethyl lactate, ethyl 3-methoxy-propionate, methyl 3-ethoxy-propionate, ethyl 3-ethoxy-propionate, 3-methyl-3-methoxybutyl propionate, n-butyl acetate, i-butyl acetate, n-amyl formate, i-amyl acetate, n-butyl propionate, ethyl butyrate, i-propyl butyrate, n-butyl butyrate, and ethyl pyruvate.

The solvent may be used alone or in a mixture of two or more.

[0134]

In addition, in combination with the solvent, a solvent having a high boiling point such as benzyl ethyl ether, di-n-hexyl ether, acetonyl acetone, isophorone, caproic acid, caprylic acid, 1-octanol, 1-nonanol, benzyl alcohol, benzyl acetate, ethyl benzoate, diethyl oxalate, diethyl maleate, γ-butyrolactone, ethylene carbonate, propylene carbonate, or ethylene glycol monophenyl ether acetate may be used.

Those solvents each having a high boiling point may be used alone or in a mixture of two or more.

The content of the solvent is not particularly limited, but from the viewpoint of spreadability, stability, or the like of the radiation-sensitive composition to be obtained, the total concentration of respective components excluding the solvent for the composition is 5 to 50 wt% is generally preferredwith 10 to 40 wt% being particularly desired.

[0135]

Color Filter

The color filter of the present invention includes a coloring layer formed by using the radiation-sensitive composition for forming a coloring layer of the present invention.

Hereinafter, a method of forming the color filter of the present invention will be described.

First, a light-shielding layer is formed on the surface of a substrate as required so as to mark off a portion on which a pixel is formed. The liquid composition of the radiation-sensitive composition of the present invention in which a red pigment is dispersed is applied onto the substrate and then pre-baked to evaporate a solvent, thereby forming a coating film. Next, the coating film is exposed to light through a photomask and then developed by using an alkalin developer. An unexposed part of the coating film is dissolved, removed, and then post-baked to form a pixel array in which a red pixel pattern is formed in accordance with a predetermined arrangement.

After that, the liquid composition of each radiation-sensitive composition in which a green or blue pigment is dispersed is used, and, in the same manner as that described above, coating, pre-baking, exposure, development, and post-baking of the each liquid composition are performed to form a green pixel array and a blue pixel array on the same substrate

sequentially, thereby obtaining a color filter in which pixel arrays having three primary colors of red, green, and blue are formed on the substrate. It should be noted that, in the present invention, the order of forming each color pixel is not limited to that as described above.

Further, a black matrix may be formed in the same manner as in the case of forming the pixel, by using the radiation-sensitive composition for forming a coloring layer of the present invention.

[0136]

Examples of the substrate to be used in forming the pixel and/or the black matrix may include glass, silicon, polycarbonate, polyester, aromatic polyamide, polyamideimide, and polyimide.

Further, those substrates may be subjected to an appropriate pretreatment such as chemical treatment with a silane coupling agent or the like, plasma treatment, ion plating, sputtering, chemical vapor deposition, or vacuum deposition, as desired.

When the liquid composition of the radiation-sensitive composition is applied onto the substrate, there may be employed an appropriate coating method such as a spray method, a roll coating method, a spin coat method, a slit-die coating method, a bar coating method, or an ink-jet method, and the spin coat method and the slit-die coating method are

particularly preferred.

The coating thickness is, as a film thickness after drying, generally 0.1 to 10 μm, preferably 0.2 to 8.0 μm, and particularly preferably 0.2 to 6.0 μm.

[0137]

As radiation used in forming the pixel and/or the black matrix, there may be used, for example, visible light ray, ultraviolet ray, far ultraviolet ray, electron ray, or X-ray, and radiation having a wavelength ranging from 190 to 450 nm is preferred.

The exposure dose of radiation is preferably 10 to 10,000 J/m^2.

In addition, examples of the alkalin developer include an aqueous solution of sodium carbonate, sodium hydroxide, potassium hydroxide, tetramethyl ammonium hydrooxide, choline, 1,8-diazabicyclo-[5.4.0]-7-undecane, or 1,5-diazabicyclo-[4.3.0]-5-nonene is preferred.

The alkalin developer may be also added with a water-soluble organic solvent such as methanol or ethanol, a surfactant, or the like in an appropriate amount. It should be noted that washing is generally performed with water after alkali development.

As a development treatment method, there may be applied, for example, a shower development method, a spray development method, a dip (immersion) development method, or a paddle

(liquid heap) development method. The development condition is preferably at normal temperature for 5 to 300 seconds.

[0138]

The thus obtained color filter of the present invention is extremely useful for a high-definition color liquid crystal display device, a color image pickup tube element, a color sensor, or the like.

[0139]

Color liquid crystal display device

The color liquid crystal display device of the present invention includes the color filter of the present invention.

Further, as one embodiment of the color liquid crystal display device of the present invention, the radiation-sensitive composition for forming a coloring layer of the present invention may be used to form a pixel and/or a black matrix on a thin film transistor substrate array as described above, thereby producing a color liquid crystal display device having particularly high-definition.

Examples [0140]

Hereinafter, embodiments of the present invention are described more specifically by way of examples. However, the present invention is not limited to the following examples.

Mw and Mn of the resin obtained in the following synthesis examples were measured by gel permeation chromatography (GPC) having the following specifications.

Apparatus: GPC-101 (manufactured by SHOWA DENKO K.K.)

Column: GPC-KF-801, GPC-KF-802, GPC-KF-803, and GPC-KF-804 were connected with each other and used.

Elution solvent: tetrahydrofuran containing 0.5 wt% of phosphoric acid

[0141]

Synthesis of alkali-soluble resin

Synthesis Example 1

A flask equipped with a condenser and a stirrer is fed with 3 parts by weight of 2,2'-azobisisobutyronitrile and 200 parts by weight of propylene glycol monomethyl ether acetate, and subsequently fed with 20 parts by weight of methacrylic acid, 30 parts by weight of N-phenylmaleimide, 30 parts by weight of benzyl methacrylate, 20 parts by weight of styrene, and 5 parts by weight of α-methylstyrene dimer (chain transfer agent) as a molecular weight controlling agent, followed by purging with nitrogen. The reaction solution was then heated to 80°C while stirring gently and polymerized for 3 hours while maintaining the temperature. 0.5 part by weight of 2,2'-azobisisobutyronitrile was added thereto and further polymerized for 1 hour. After that, the reaction solution was heated to 100°C and continuously polymerized for 1 hour, to thereby obtain a resin solution (solids concentration=33.0 wt%). The obtained resin had Mw=9,500 and Mw/Mn=2.0. The resin is taken to be a "resin (B-1)".

[0142]

Synthesis Example 2

A flask equipped with a condenser and a stirrer is fed with 4 parts by weight of 2,2'-azobisisobutyronitrile and 200 parts by weight of propylene glycol monomethyl ether acetate, and subsequently fed with 15 parts by weight of methacrylic acid, 20 parts by weight of N-phenylmaleimide, 35 parts by weight of benzyl methacrylate, 10 parts by weight of styrene, 10 parts by weight of glycerol monomethacrylate, 10 parts by weight of ω-carboxy-polycaprolactone monoacrylate, and 6 parts by weight of α-methylstyrene dimer (chain transfer agent) as a molecular weight controlling agent, followed by purging with nitrogen. The reaction solution was then heated to 80°C while stirring gently and polymerized for 3 hours while maintaining the temperature. 0.5 part by weight of 2,2'-azobisisobutyronitrile was added thereto and further polymerized for 1 hour. After that, the reaction solution was heated to 100°C and continuously polymerized for 1 hour, to thereby obtain a resin solution (solids concentration=33.0 wt%). The obtained resin had Mw=7,500 and Mw/Mn=2.1. The resin is taken to be a "resin (B-2)".

[0143]

Synthesis Example 3

A flask equipped with a condenser and a stirrer is fed with 3 parts by weight of 2,2'-azobisisobutyronitrile and 200

parts by weight of propylene glycol monomethyl ether acetate, and subsequently fed with 15 parts by weight of methacrylic acid, 30 parts by weight of acenephthylene, 40 parts by weight of benzyl methacrylate, 10 parts by weight of glycerol monomethacrylate, 5 parts by weight of ω-carboxy-polycaprolactone monoacrylate, and 5 parts by weight of α-methylstyrene dimer (chain transfer agent) as a molecular weight controlling agent, followed by purging with nitrogen. The reaction solution was then heated to 80°C while stirring gently and polymerized for 3 hours while maintaining the temperature. 0.5 part by weight of 2,2'-azobisisobutyronitrile was added thereto and further polymerized for 1 hour. After that, the reaction solution was heated to 100°C and continuously polymerized for 1 hour, to thereby obtain a resin solution (solids concentration=33.0 wt%). The obtained resin had Mw=11,000 and Mw/Mn=2.2. The resin is taken to be a "resin (B-3)".

[0144]

Synthesis Example 4

A flask equipped with a condenser and a stirrer is fed with 3 parts by weight of 2,2'-azobisisobutyronitrile and 200 parts by weight of propylene glycol monomethyl ether acetate, and subsequently fed with 15 parts by weight of methacrylic acid, 25 parts by weight of N-phenylmaleimide, 25 parts by weight of benzyl methacrylate, 15 parts by weight of styrene,

10 parts by weight of glycerol monomethacrylate, 10 parts by weight of ω-carboxy-polycaprolactone monoacrylate, and 5 parts by weight of α-methylstyrene dimer (chain transfer agent) as a molecular weight controlling agent, followed by purging with nitrogen. The reaction solution was then heated to 80°C while stirring gently and polymerized for 3 hours while maintaining the temperature. 0.5 part by weight of 2,2'-azobisisobutyronitrile was added thereto and further polymerized for 1 hour. After that, the reaction solution was heated to 100°C and continuously polymerized for 1 hour, to thereby obtain a resin solution (solids concentration=33.0 wt%). The obtained resin had Mw=10,000 and Mw/Mn=2.2. The resin is taken to be a "resin (B-4)".

[0145]

Synthesis Example 5

A flask equipped with a condenser and a stirrer is fed with 4 parts by weight of 2,2'-azobisisobutyronitrile and 200 parts by weight of propylene glycol monoethyl ether, and subsequently fed with 15 parts by weight of methacrylic acid, 30 parts by weight of acenaphthylene, 35 parts by weight of benzyl methacrylate, 20 parts by weight of glycerol monomethacrylate, and 6 parts by weight of α-methylstyrene dimer (chain transfer agent) as a molecular weight controlling agent, followed by purging with nitrogen. The reaction solution was then heated to 80°C while stirring gently and

polymerized for 3 hours while maintaining the temperature. 0.5 part by weight of 2,2'-azobisisobutyronitrile was added thereto and further polymerized for 1 hour. After that, the reaction solution was heated to 100°C and continuously polymerized for 1 hour, to thereby obtain a resin solution (solids concentration=33.0 wt%). The obtained resin had Mw=12,000 and Mw/Mn=2.2. The resin is taken to be a "resin (B-5)".

[0146]

Synthesis Example 6

In a flask equipped with a condenser and a stirrer, 40 parts by weight of p-vinylbenzyl glycidyl ether, 27 parts by weight of N-phenylmaleimide, 17 parts by weight of styrene, and 16 parts by weight of benzyl methacrylate were dissolved in 300 parts by weight of propylene glycol monomethyl ether acetate. Further, 4 parts by weight of 2,2'-azobisisobutyronitrile and 6 parts by weight of α-methylstyrene dimer were poured into the mixture, followed by purging with nitrogen for 15 minutes. After purging with nitrogen, the reactor was heated to 80°C while stirring, followed by reaction for 5 hours, to thereby obtain a resin solution containing 25 wt% of a styrene epoxy resin. The styrene epoxy resin had Mw=6,000 and Mw/Mn=2.5.

A flask is fed with 200 parts by weight of the obtained resin solution containing a styrene epoxy resin, 10 parts by

weight of methacrylic acid as the unsaturated monocarboxylic acid (X), 0.2 part by weight of p-methoxyphenol, 0.2 part by weight of tetrabutylammonium bromide, and 300 parts by weight of propylene glycol monomethyl ether acetate, followed by reaction at 120°C for 9 hours. Here, 1 equivalent of methacrylic acid was reacted with respect to 1 equivalent of the epoxy group of the styrene epoxy resin. Still further, 16 parts by weight of 4-cyclohexene-1,2-dicarboxylic acid anhydride as the polybasic acid anhydride (y) were added to the reaction solution, followed by reaction at 80°C for 6 hours. The reaction mixture was rinsed twice with water while maintaining the solution temperature thereof at 80°C, and was subjected to vacuum concentration, to thereby obtain a resin solution containing 20 wt% of an alkali-soluble resin. The obtained resin had Mw=7,800 and Mw/Mn=2.6. The resin is taken to be a "resin (B-6)".

[0147]

Preparation of pigment dispersion liquid

Preparation Example 1

A pigment dispersion liquid (r) was prepared by treating in a beads mill, 15 parts by weight of a mixture of C.I. Pigment Red 254 and C.I. Pigment Red 177 at a ratio of 80/20 (weight ratio) as the colorant (A), 4 parts by weight (in terms of solid content) of Disperbyk-2001 as a dispersant, 6 parts by weight (in terms of solid content) of the resin (B-1)

as the alkali-soluble resin (B), and 75 parts by weight of propylene glycol monomethyl ether acetate as a solvent.

[0148]

Preparation Example 2

A pigment dispersion liquid (g) was prepared by treating in the same manner as that in Preparation Example 1, 15 parts by weight of a mixture of C.I. Pigment Green 36, C.I. Pigment Yellow 138, and C.I. Pigment Yellow 150 at a ratio of 50/40/10 (weight ratio) as the colorant (A), 4 parts by weight (in terms of solid content) of Disperbyk-2001 as a dispersant, 5 parts by weight (in terms of solid content) of the resin (B-2) as the alkali-soluble resin (B), and 76 parts by weight of propylene glycol monomethyl ether acetate as a solvent.

[0149]

Preparation Example 3

A pigment dispersion liquid (b) was prepared by treating in the same manner as that in Preparation Example 1, 15 parts by weight of a mixture of C.I. Pigment Blue 15:6 and C.I. Pigment Violet 23 at a ratio of 95/5 (weight ratio) as the colorant (A), 4 parts by weight (in terms of solid content) of Disperbyk-2001 as a dispersant, 5 parts by weight (in terms of solid content) of the resin (B-2) as the alkali-soluble resin (B), and 76 parts by weight of propylene glycol monomethyl ether acetate as a solvent.

[0150]

Preparation Example 4

A pigment dispersion liquid (bk1) was prepared by treating in the same manner as that in Preparation Example 1, 20 parts by weight of a carbon black (manufactured by Mikuni Color Ltd.) as the colorant (A), 2 parts by weight (in terms of solid content) of Disperbyk-2001 as a dispersant, 4 parts by weight (in terms of solid content) of the resin (B-3) as the alkali-soluble resin (B), and 74 parts by weight of 3-methoxybutyl acetate as a solvent.

[0151]

Preparation Example 5

A pigment dispersion liquid (bk2) was prepared by treating in the same manner as that in Preparation Example 1, 20 parts by weight of a carbon black (manufactured by Mikuni Color Ltd.) as the colorant (A), 2 parts by weight (in terms of solid content) of Disperbyk-167 as a dispersant, 3 parts by weight (in terms of solid content) of the resin (B-3) as the alkali-soluble resin (B), and 75 parts by weight of 3-methoxybutyl acetate as a solvent.

[0152]

Example 1

Preparation of liquid composition

100 parts by weight of the pigment dispersion liquid (r), 6 parts by weight (in terms of solid content) of the resin (B-4) as the alkali-soluble resin (B), 8 parts by weight of

dipentaerythritol hexaacrylate as the polyfunctional monomer (C), 3 parts by weight of 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one (trade name: IRGACURE 369, manufactured by Ciba Specialty Chemicals Inc.) as the radiation-sensitive radical generating agent (D), 0.15 part by weight of 4,4'-[1-[4-[1-[4-hydroxyphenyl]-1-methylethyl]phenyl]ethylidene]bisphenol as the component (E), and 150 parts by weight of ethyl 3-ethoxypropionate and 25 parts by weight of propylene glycol monomethyl ether acetate as solvents were mixed, to thereby prepare a liquid composition (R1) for forming a coloring layer.

The liquid composition (R1) was evaluated in accordance with the following procedure. The evaluation results are shown in Table 2.

[0153]

Formation of pattern

The liquid composition (R1) was applied onto a glass substrate by using a spin coater, and then pre-baked at 90°C for 2 minutes to form a coating film having a film thickness of 2.5 μm. After that, the substrate was cooled to room temperature, and then the coating film was exposed to radiation in an exposure dose of 1,000 J/m^2 through a photomask (exposure gap of 200 μm) by using a high-pressure mercury lamp. Then, a shower development was performed for 50 seconds by discharging 0.04 wt% by weight of an aqueous potassium

hydroxide solution at 23°C onto the coating film on the substrate under the condition of a development pressure of 2 kgf/cm^2 (nozzle size of 1 mm). After that, the substrate was post-baked at 230°C for 30 minutes to form a pixel array in which red line and space (L/S) pattern was arranged on the substrate.

[0154]

Evaluation

The pixel pattern on the substrate was observed with a light microscope, and chipping on a pixel pattern edge was not confirmed. Further, the cross section of the pixel pattern on the substrate was observed with a scanning electron microscope (SEM), and no undercut was confirmed. The line width of the pixel pattern which was formed through a photomask having a slit width of 90 μm was measured with the light microscope, and found to be 93.0 μm.

[0155]

Examples 2 to 17 and Comparative Examples 1 to 6

Liquid compositions (R2) and (R3), (G1) to (G3), (B1) to (B3), and (BK1) to (BK14) were prepared in the same manner as that in Example 1, except that types and amounts of constituent components were changed as shown in Table 2.

Next, evaluations were performed in the same manner as that in Example 1, except that the liquid compositions (R2) and (R3), (G1) to (G3), (B1) to (B3), and (BK1) to (BK14) were

each used instead of the liquid composition (R1). The results are shown in Table 2.

[0156]

[Table 1]

	Liquid Compo-sition	Pigment dispersion liquid		Component B		Component C		Component D		Component E		Additive		Solvent	
		Type	Part by weight	Type	Part by weight	Type	Part by weight	Type	Part by weigh t	Type	Part by weigh t	Type	Part by weight	Type	Part by weight
Ex. 1	R1	r	100	B-4	6	C-1	8	D-1	3	E-1	0.15	-	-	EEP/PGMEA	150/25
Ex .2	R2	r	100	B-5	6	C-1	8	D-1	3	E-1	0.15	-	-	EEP/PGMEA	150/25
Ex. 3	G1	g	100	B-4	7	C-1	8	D-1	3	E-1	0.15	F-1	0.1	MBA/PGMEA	125/50
Ex. 4	G2	g	100	B-5	7	C-1	8	D-1	3	E-1	0.15	F-1	0.1	MBA/PGMEA	125/50
Ex. 5	B1	b	100	B-4	6	C-1	9	D-2	3	E-1	0.15	F-2	0.5	EEP/PGMEA	150/25
Ex. 6	B2	b	100	B-5	6	C-1	9	D-2	3	E-1	0.15	F-2	0.5	EEP/PGMEA	150/25
Ex. 7	BK1	bk1	100	B-5	5	C-1	6	D-3	3	E-1	0.1	F-2	0.5	MBA/PGMEA	125/50
Ex. 8	BK2	bk1	100	B-6	5	C-1	6	D-3	3	E-1	0.1	F-2	0.5	MBA/PGMEA	125/50
Ex. 9	BK3	bk2	100	B-5	3	C-1	6	D-3	2.5	E-1	0.08	F-2	0.5	MBA/PGMEA	125/50
Ex. 10	BK4	bk2	100	B-5	3	C-1/C-2	4/2	D-3	2.5	E-1	0.08	F-2	0.5	MBA/PGMEA	125/50
Ex. 11	BK5	bk2	100	B-6	3	C-1	6	D-3	2.5	E-1	0.08	F-2	0.5	MBA/PGMEA	125/50
Ex. 12	BK6	bk2	100	B-5	3	C-1	6	D-3	2.5	E-1	0.02	F-2	0.5	MBA/PGMEA	125/50
Ex. 13	BK7	bk2	100	B-5	3	C-1	6	D-3	2.5	E-1	0.40	F-2	0.5	MBA/PGMEA	125/50
Ex. 14	BK8	bk2	100	B-5	3	C-1	6	D-3	2.5	E-2	0.08	F-2	0.5	MBA/PGMEA	125/50
Ex. 15	BK9	bk2	100	B-5	3	C-1	6	D-3	2.5	E-3	0.08	F-2	0.5	MBA/PGMEA	125/50
Ex. 16	BK10	bk2	100	B-5	3	C-1	6	D-3	2.5	E-4	0.08	F-2	0.5	MBA/PGMEA	125/50
Ex. 17	BK11	bk2	100	B-5	3	C-1	6	D-3	2.5	E-5	0.04	F-2	0.5	MBA/PGMEA	125/50
Com. Ex.1	R3	r	100	B-4	6	C-1	8	D-1	3	-	-	-	-	EEP/PGMEA	150/25
Com. Ex.2	G3	g	100	B-4	7	C-1	8	D-1	3	-	-	F-1	0.1	MBA/PGMEA	125/50
Com. Ex.3	B3	b	100	B-4	6	C-1	9	D-2	3	-	-	F-2	0.5	EEP/PGMEA	150/25
Com. Ex.4	BK12	bk1	100	B-5	5	C-1	6	D-3	3	-	-	F-2	0.5	MBA/PGMEA	125/50
Com. Ex.5	BK13	bk2	100	B-5	3	C-1	6	D-3	2.5	-	-	F-2	0.5	MBA/PGMEA	125/50
Comp. Ex.6	BK14	bk2	100	B-5	3	C-1	6	D-3	2.5	-	-	F-2/F-3	0.5/0.08	MBA/PGMEA	125/50

Note: Component B: Alkali-soluble resin

Component C: Polyfunctional monomer

Component D: Radiation-sensitive radical generating agent

[0157]

In Table 1, respective components are as follows.

C-1: dipentaerythritol hexaacrylate

C-2: tris(2-hydroxyethyl)isocyanurate triacrylate (trade name: M-315, manufactured by Toagosei Co., Ltd.)

D-1: 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one (trade name: IRGACURE 369, manufactured by Ciba Specialty Chemicals Inc.)

D-2: 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropane-1-one (trade name: IRGACURE 907, manufactured by Ciba Specialty Chemicals Inc.)

D-3: ethanone, 1-[9-ethyl-6-(2-methylbenzoyl)-9.H.-carbazol-3-yl]-, 1-(o-acetyloxime) (trade name: IRGACURE OX02, manufactured by Ciba Specialty Chemicals Inc.)

E-1: 4,4'-[1-[4-[1-[4-hydroxyphenyl]-1-methylethyl]phenyl]ethylidene]bisphenol

E-2: 2,3,4-trihydroxybenzophenone

E-3: 2,3,4,4'-tetrahydroxybenzophenone

E-4: 2-methyl-2-(2,4-dihydroxyphenyl)-4-(4-hydroxyphenyl)-7-hydroxychroman

E-5: 2,3,4,2',6'-pentahydroxybenzophenone

F-1: malonic acid

F-2: nonionic surfactant (trade name: A-60, manufactured by Kao Corporation)

F-3: polymerization inhibitor phenothiazine

EEP: ethyl 3-ethoxypropionate

PGMEA: propylene glycol monomethyl ether acetate

MBA: 3-methoxybutyl acetate

[0158]

[Table 2]

	Liquid composition	Pattern shape		Formed pattern line width (μm)		
		Undercut	Chipping	Photomask having slit width of 90 μm	Photomask having slit width of 30 μm	Photomask having slit width of 10 μm
Ex. 1	R1	Not confirmed	Not confirmed	93.0	-	-
Ex. 2	R2	Not confirmed	Not confirmed	93.5	-	-
Ex. 3	G1	Not confirmed	Not confirmed	92.5	-	-
Ex. 4	G2	Not confirmed	Not confirmed	93.1	-	-
Ex. 5	B1	Not confirmed	Not confirmed	92.4	-	-
Ex. 6	B2	Not confirmed	Not confirmed	93.3	-	-
Ex. 7	BK1	Not confirmed	Not confirmed	-	31.7	12.5
Ex. 8	BK2	Not confirmed	Not confirmed	-	32.1	12.6
Ex. 9	BK3	Not confirmed	Not confirmed	-	29.8	10.5
Ex. 10	BK4	Not confirmed	Not confirmed	-	32.0	12.8
Ex. 11	BK5	Not confirmed	Not confirmed	-	30.5	11.2
Ex. 12	BK6	Not confirmed	Not confirmed	-	35.7	16.2
Ex. 13	BK7	Confirmed	Not confirmed	-	24.2	Peeled
Ex. 14	BK8	Not confirmed	Not confirmed	-	31.2	12.0
Ex. 15	BK9	Not confirmed	Not confirmed	-	29.1	9.9
Ex. 16	BK10	Not confirmed	Not confirmed	-	29.3	10.1
Ex. 17	BK11	Not confirmed	Not confirmed	-	30.8	11.5
Com. Ex. 1	R3	Not confirmed	Not confirmed	99.0	-	-
Com. Ex. 2	G3	Not confirmed	Not confirmed	98.2	-	-
Com. Ex. 3	B3	Not confirmed	Not confirmed	97.2	-	-
Com. Ex. 4	BK12	Not confirmed	Not confirmed	-	36.5	17.5
Com. Ex. 5	BK13	Not confirmed	Not confirmed	-	36.1	16.8
Com. Ex.6	BK14	Confirmed	Confirmed	-	26.5	Peeled

[0159]

The radiation-sensitive composition containing the component (E) of the present invention may form a pixel and a black matrix each of which is excellent in adhesion to a substrate even in the case where the content of a colorant contained in the radiation-sensitive composition is high, has a high-definition and excellent pattern form, and is free from a pattern line width being thickened even in proximity exposure.

Therefore, the radiation-sensitive composition of the present invention may be remarkably suitably used for producing various color filters such as a color filter for a color liquid crystal display device and a color filter for color separation of a solid-state image pickup device in the electronic industry field.

WHAT IS CLAIMED IS:

1. A radiation-sensitive composition for forming a coloring layer, comprising:

a colorant (A);

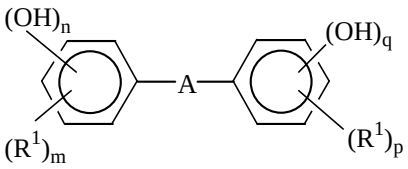
an alkali-soluble resin (B);

a monomer having two or more radical polymerizable unsaturated bonds (C);

a radiation-sensitive radical generating agent (D); and

at least one kind of compound (E), which is selected from the group consisting of:

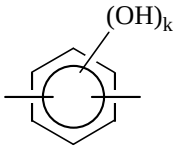
compounds represented by the following formulae (1) to (5):



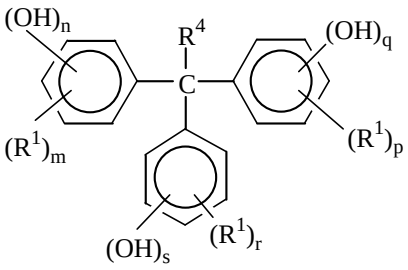
(1)

where: R^1's each represent a hydrogen atom, an alkyl group having 4 or less carbon atoms, an alkoxy group having 4 or less carbon atoms, a phenyl group, a naphthyl group, or a $-(CH_2)_x-COOZ$ group, and a plurality of R^1's may be identical to or different from each other; Z represents an alkoxyalkyl group, a cyclic ether group, a vinyloxyalkyl group, or a t-alkoxycarbonylalkyl group, and a plurality of Z's may be identical to or different from each other; x represents an integer of 0 to 4; A represents a single bond, an -S- group,

an -O- group, a -CO- group, a -COO- group, an -SO- group, an -SO_2- group, a -$C(R^2)(R^3)$- group, or a

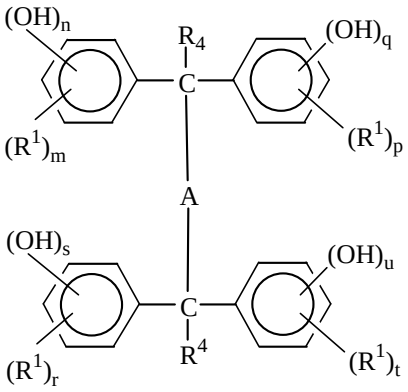


group provided that k represents an integer of 0 to 4; R^2 and R^3 may be identical to or different from each other and each represent a hydrogen atom, an alkyl group having 6 or less carbon atoms, an acyl group having 6 or less carbon atoms, a phenyl group, a naphthyl group, or a $-(CH_2)_x$-COOZ group; and m, n, p, and q each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, and $n+q \geq 1$;



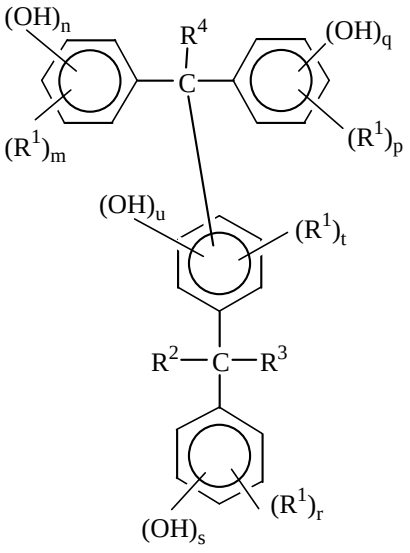
(2)

where: R^1's each represent the same group as R^1 in the formula (1); R^4 represents the same group as R^2 in the formula (1); and m, n, p, q, r, and s each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, $r+s \leq 5$, and $n+q+s \geq 1$;



(3)

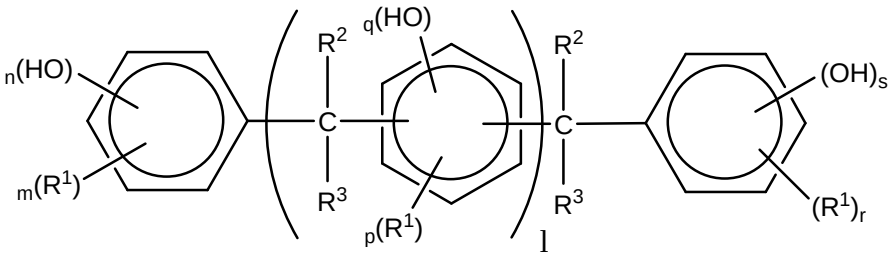
where: R^1's each represent the same group as R^1 in the formula (1); R^4's each represent the same group as R^2 in the formula (1) and two R^4's may be identical to or different from each other; A represents the same group as A in the the formula (1); and m, n, p, q, r, s, t, and u each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, $r+s \leq 5$, $t+u \leq 5$, and $n+q+s+u \geq 1$;



(4)

where: R^1's each represent the same group as R^1 in the formula (1); R^2, R^3, and R^4 represent the same groups as R^2 in the formula (1), R^3 in the formula (1), and R^4 in the

formula (2), respectively; and m, n, p, q, r, s, t, and u each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 5$, $r+s \leq 5$, $t+u \leq 4$, and $n+q+s+u \geq 1$; and



(5)

where: R^1's, R^2's, and R^3's represent the same groups as R^1, R^2, and R^3 in the formula (1), respectively; m, n, p, q, r, and s each represent an integer of 0 or more and satisfy relationships of $m+n \leq 5$, $p+q \leq 4$, $r+s \leq 5$, and $n+q+s \geq 2$; and l represents an integer of 1 to 5;

a phenolic compound having a flavan structure;

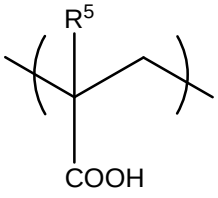
a phenolic compound having a spirobiindane structure; and

a phenolic compound having a spirobiindene structure.

2. The radiation-sensitive composition for forming a coloring layer according to claim 1, wherein a content of the compound (E) is 0.1 to 10 parts by weight with respect to 100 parts by weight of the alkali-soluble resin (B).

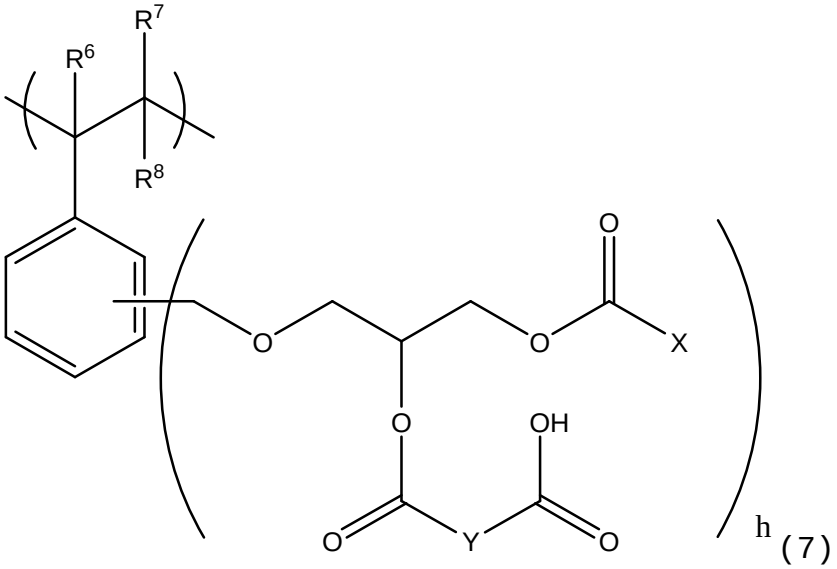
3. The radiation-sensitive composition for forming a

coloring layer according to claim 1 or 2, wherein the alkali-soluble resin (B) comprises at least one kind selected from the group consisting of a polymer having a repeating unit represented by the following formula (6) and a polymer having a repeating unit represented by the following formula (7):



(6)

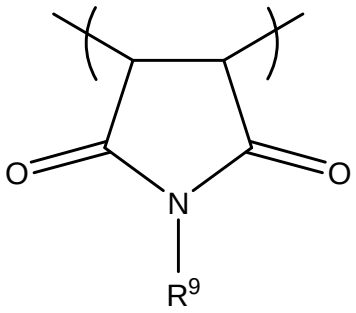
where R^5 represents a hydrogen atom or a methyl group; and



(7)

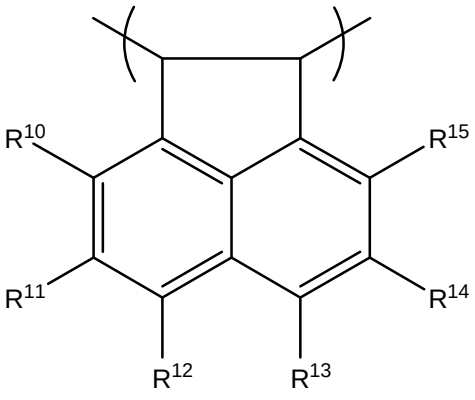
where: R^6, R^7, and R^8 each independently represent a hydrogen atom or an alkyl group having 1 to 10 carbon atoms; X represents a monovalent organic group having an acryloyl group or a methacryloyl group, a vinyl group, or a 1-methylvinyl group; Y represents a divalent organic group; and h represents an integer of 1 to 5.

4. The radiation-sensitive composition for forming a coloring layer according to claim 3, wherein the alkali-soluble resin (B) further contains a polymer having at least one kind of repeating unit selected from the group consisting of a repeating unit represented by the following formula (8) and a repeating unit represented by the following formula (9):



(8)

where R^9 represents a linear, branched, or cyclic alkyl group having 1 to 12 carbon atoms or an aryl group having 6 to 12 carbon atoms; and



(9)

where R^{10} to R^{15} each independently represent a hydrogen atom, a halogen atom, a hydroxyl group, a hydroxymethyl group, or a carboxyl group.

5. The radiation-sensitive composition according to any one of claims 1 to 4, wherein a content of the colorant (A) is 30 to 60 wt% with respect to a total solid content.

6. A color filter comprising a coloring layer formed by using the radiation-sensitive composition for forming a coloring layer according to any one of claims 1 to 5.

7. A color liquid crystal display device comprising the color filter according to claim 6.