

**RADIATION-SENSITIVE COMPOSITION FOR A RED COLOR FILTER,
COLOR FILTER AND COLOR LIQUID CRYSTAL DISPLAY DEVICE**

BACKGROUND OF THE INVENTION

Field of the Invention

[0001]

The present invention relates to a radiation-sensitive composition for a red color filter, a color filter and a color liquid crystal display device, and more particularly, to a radiation-sensitive composition for use in manufacturing a red color filter used in a transmissive or reflective color liquid crystal device and a color imaging device etc., a color filter having pixels formed by using the radiation-sensitive composition and a color liquid crystal display device having the color filter.

Description of the Related Art

[0002]

As a method for forming a color filter using a colored radiation-sensitive composition, a method including forming a coating of a colored radiation-sensitive composition on a substrate or a substrate having a light-shielding layer with a desired pattern previously formed thereon, irradiating (hereinafter, referred to as "exposure") it with radiation through a photomask having a desired pattern, developing it to

dissolve and remove unexposed portions, and thereafter, subjecting it to post-baking to obtain pixels of various colors (see, for example, Patent Documents 1 and 2) is known.

In such a liquid crystal display device having such a color filter, it has been desired to increase the brightness and color reproduction area. Therefore, it has been recently desired to develop a color filter having higher light transmittance and higher chromatic purity.

[0003]

For a radiation-sensitive composition for a red color filter, various ideas have been proposed in order to achieve a high balance between brightness and chromatic purity. For example, Patent Documents 3 and 4 disclose use of C.I. pigment red 254 in combination with various yellow pigments or orange pigments. However, the combination of C.I. pigment red 254 and a yellow pigment such as C.I. pigment yellow 139 is insufficient to obtain a red color filter having high brightness. The combination of C.I. pigment red 254 and an orange pigment such as C.I. pigment orange 38 is insufficient to obtain a red color filter having high chromatic purity. To enlarge a color reproduction area of a color filter, the film thickness of the formed coating must be increased. As a result, the in-plane uniformity of the coating tends

to significantly decrease and unfavorable in view of productivity.

Meanwhile, Patent Documents 5 and 6 disclose use of C.I. pigment red 254 in combination with C.I. pigment red 242. Such combination is suitable in obtaining a red color filter having high brightness but unsatisfactory in obtaining a red color filter having high chromatic purity.

In view of the aforementioned background, it has been strongly desired to develop a radiation-sensitive composition for a red color filter capable of forming pixels satisfying the requirements for further higher light transmittance and higher chromatic purity.

[0004]

[Patent Document 1] JP-A-2-144502

[Patent Document 2] JP-A-3-53201

[Patent Document 3] JP-A-10-227911

[Patent Document 4] JP-A-11-217514

[Patent Document 5] JP-A-11-14824

[Patent Document 6] JP-A-2002-372618

SUMMARY OF THE INVENTION

[0005]

An object of the invention is to provide a radiation-sensitive composition for a color filter, capable of forming red pixels having high light transmittance and high chromatic purity without increasing the film thickness of a coating and the

content of a pigment component in the radiation-sensitive composition.

Another object of the present invention is to provide a color filter having pixels formed by using the radiation-sensitive composition for the color filter, and a color liquid crystal display device having the color filter.

[0006]

The present inventors have conducted intensive studies. As a result, they found that the aforementioned problems can be overcome by introducing C.I. pigment red 166 as a red pigment and achieved the present invention.

[0007]

The present invention therefore provides firstly a radiation-sensitive composition for forming a colored layer, more specifically, a radiation-sensitive composition for a red color filter containing (A) a colorant, (B) an alkaline soluble resin, (C) a polyfunctional monomer and (D) a photopolymerization initiator, in which, (A) the colorant includes (A1) C.I. pigment red 166 and (A2) at least one pigment selected from the group consisting of C.I. pigment red 224, C.I. pigment red 242 and C.I. pigment red 254.

The "radiation" used in the present invention refers to those including visible rays, ultraviolet rays, far-ultraviolet rays, electron beams and X-rays.

[0008]

Secondly, the present invention provides a color filter having a red color filter formed by using the radiation-sensitive composition.

Thirdly, the present invention provides a color liquid crystal display device having the color filter.
[0009]

The present invention will be more specifically described below.

Radiation-Sensitive Composition for Red Color Filter

- (A) colorant -

The colorant of the present invention essentially contains (A1) C.I. pigment red 166 classified based on the Color Index (C.I., The Society of Dyers and Colourists, the same abbreviation will be used below) and further contains (A2) at least one pigment selected from the group consisting of C.I. pigment red 224, C.I. pigment red 242 and C.I. pigment red 254 (these will be sometimes collectively referred to as "colorant (A2)"). A radiation-sensitive composition for a color filter capable of forming red pixels having high light transmittance and high chromatic purity can be obtained by appropriately controlling color by blending these pigments in combination.

The radiation-sensitive composition of the present invention is used to form red pixels and may further contain a red pigment other than the aforementioned ones, a yellow pigment or an orange pigment. Such a red,

yellow or orange pigment is not particularly limited; however, an organic pigment is preferred since emission of a color having high chromatic purity and high light transmittance and heat resistance are required for a color filter.

[0010]

As other red organic pigments mentioned above, for example, compounds classified as pigments based on a color index, more specifically compounds assigned with the following color index (C.I.) numbers may be mentioned.

[0011]

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 168, C.I. pigment red 170, C.I. pigment red 171, C.I. pigment red 176, C.I. pigment red 177, C.I. pigment red 178, C.I. pigment red 179, C.I. 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 243, C.I. pigment red 255, C.I. pigment red 262, C.I. pigment red 264 and C.I. pigment red 272.

[0012]

As the yellow organic pigments, for example, compounds classified as pigments based on a color index,

more specifically compounds assigned with the following color index (C.I.) numbers may be mentioned.

[0013]

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.

[0014]

As the orange organic pigments, for example, compounds classified as pigments based on a color index, more specifically compounds assigned with the following color index (C.I.) numbers may be mentioned.

[0015]

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.

[0016]

Of these organic pigments, from the view points of light transmittance and chromatic purity, the yellow organic pigments or the orange organic pigments are preferred, particularly, C.I. pigment yellow 83, C.I. pigment yellow 138, C.I. pigment yellow 139, C.I. pigment yellow 150, C.I. pigment orange 38 and C.I. pigment orange 71 are preferred.

These organic pigments may be used alone or as a mixture of two or more thereof.

[0017]

In the colorant of the present invention, the content of (A1) C.I. pigment red 166 is not particularly limited; however, preferably 20 to 95% by weight and particularly preferably 30 to 90% by weight based on the total amount of the colorants. Also, the content of the colorant (A2) is not particularly limited; however, preferably 1 to 80% by weight and particularly preferably 5 to 70% by weight based on the total amount of the colorants. Red pixels having high light transmittance and high chromatic purity and being excellent in solvent resistance can be obtained by using such colorants.

When the organic pigments other than the colorants (A1) and (A2) are contained, the content thereof is preferably 1 to 60% by weight, and particularly

preferably 5 to 40% by weight based on the total amount of the colorants.

In the present invention, C.I. pigment red 166 and the pigments other than C.I. pigment red 166 may be purified, if necessary, by a re-crystallization method, a re-sedimentation method, a solvent cleaning method, a sublimation method, a vacuum-heating method and a combination thereof and then put in use.

[0018]

In the present invention, each of the pigments mentioned above, may be used after the surface of the particles thereof is modified with a polymer if desired. Examples of the polymer for use in modifying the surface of the pigment particles may include polymers described in Patent Document 7 and various polymers or oligomers for dispersing pigment particles available in the market.

[0019]

[Patent Document 7] JP-A-8-259876

[0020]

The radiation-sensitive composition of the present invention can be prepared by an appropriate method, for example, prepared by mixing (A) to (D) components together with a solvent and an additive (described later) as needed. When a pigment is used as the colorant, the composition is preferably produced by mixing and dispersing the pigment in a solvent in the presence of a dispersant or dispersion aid as needed, and optionally

together with a part of the component (B), while pulverizing the mixture by a beads mill, a roll mill or the like to obtain a pigment dispersed solution, to which the components (B) to (D), and, as needed, an additional solvent or an additive are added and mixed.

[0021]

As the dispersant to be used for preparing the pigment dispersion solution, for example, an appropriate dispersant such as cationic, anionic and nonionic or amphoteric dispersant may be used; however, a polymer dispersant is preferred. Specific examples thereof may include modified acrylic copolymers, acrylic copolymers, polyurethanes, polyesters, alkyl ammonium salts or phosphate salts of a high-molecular weight copolymer and cationic comb polymers. The cationic comb polymer mentioned herein refers to a polymer having a structure in which branched polymers of two or more molecules are grafted to a single stem-polymer molecule having a plurality of basic groups (cationic functional groups). For example, a polymer whose stem-polymer portion is constituted of polyethylene imine and whose branched polymer portion is constituted of a ring-opened polymer of ϵ -caprolactone may be mentioned. Of these dispersants, the modified acrylic copolymers, the polyurethanes and the cationic comb polymers are preferred.

These dispersants are commercially available. Examples of the modified acrylic copolymers may include

Disperbyk-2000, Disperbyk-2001 (both manufactured by BYK Chemie (BYK)). Examples of the polyurethanes may include Disperbyk-161, Disperbyk-162, Disperbyk-165, Disperbyk-167, Disperbyk-170, Disperbyk-182 (all manufactured by BYK Chemie (BYK)), Solspers 76500 (manufactured by Lubrizol Corporation). Examples of the cationic comb polymers may include Solspers 24000 and Solspers 37500 (manufactured by Lubrizol Corporation), and AJISPER PB 821, AJISPER PB 822 and AJISPER PB 880 (manufactured by Ajinomoto Fine-Techno Co., Inc.).

[0022]

The amount of the dispersant for use in preparing the pigment dispersion solution is generally, not more than 100 parts by weight, preferably 0.5 to 100 parts by weight, further preferably 1 to 70 parts by weight, and particularly preferably 10 to 50 parts by weight based on 100 parts by weight of the pigment. In this case, when the amount of the dispersant exceeds 100 parts by weight, the developing property may deteriorate.

Furthermore, as the solvent for use in preparing the pigment dispersion solution, the same as exemplified later with respect to the liquid radiation sensitive resin composition may be mentioned.

The amount of the solvent for use in preparing the pigment dispersion solution is generally, 200 to 1,200 parts by weight and preferably 300 to 1000 parts by weight based on 100 parts by weight of the pigment.

[0023]

As the dispersant aid for use in preparing the pigment dispersion solution, for example, a derivative of a pigment may be mentioned.

[0024]

- (B) Alkali-soluble resin -

The alkali-soluble resin in the present invention is not particularly limited as long as it is acted as a binder for (A) the pigment and as long as it is soluble in a developer used in a developing step for manufacturing a color filter, preferably soluble in an alkaline developer. It is preferable to contain a copolymer of (b1) (meth)acrylic acid and (b2) an N-substituted maleimide and (b3) a polymerizable unsaturated compound (hereinafter referred to as an "unsaturated compound (b3)"), from which the components (b1) and (b2) are excluded, and which may be one, or two or more compounds selected from the group consisting of styrene, α -methylstyrene, p-hydroxy- α -methylstyrene, methyl(meth)acrylate, n-butyl(meth)acrylate, 2-ethylhexyl(meth)acrylate, 2-hydroxyethyl(meth)acrylate, allyl(meth)acrylate, benzyl(meth)acrylate, glycerol mono(meth)acrylate, mono[2-(meth)acryloyloxyethyl] succinate, ω -carboxypolycaprolactone mono(meth)acrylate, a polystyrene macromonomer and a polymethylmethacrylate macromonomer.

[0025]

Examples of the N-substituted maleimide may include N-phenyl maleimide, N-o-hydroxyphenyl maleimide, N-m-hydroxyphenyl maleimide, N-p-hydroxyphenyl maleimide, N-benzyl maleimide, N-cyclohexyl maleimide, N-succinimidyl-3-maleimide benzoate, N-succinimidyl-4-maleimide butyrate, N-succinimidyl-6-maleimide caproate, N-succinimidyl-3-maleimide propionate and N-(acridinyl)maleimide. Of these N-substituted maleimides, N-phenyl maleimide, and N-cyclohexyl maleimide are preferred, particularly, N-phenyl maleimide is preferred. In (B1) the copolymer, the N-substituted maleimides may be used alone or as a mixture of two or more thereof.

[0026]

In the present invention, together with (meth)acrylic acid, the N-substituted maleimide and the unsaturated compound (b3), other unsaturated compounds (hereinafter referred to as an "unsaturated compound (b4)") polymerizable therewith are further copolymerized.

[0027]

Examples of the unsaturated compound (b4) may include maleic acid, maleic anhydride, o-vinyl phenol, m-vinyl phenol, p-vinyl phenol, o-vinylbenzyl glycidyl ether, m-vinylbenzyl glycidyl ether, p-vinylbenzyl glycidyl ether, acetylene, isobornyl(meth)acrylate, tricyclo[5.2.1.0^{2,6}]decan-8-yl(meth)acrylate, o-hydroxyphenyl(meth)acrylate, m-hydroxyphenyl(meth)acrylate, p-

hydroxyphenyl(meth)acrylate, 2-dimethylaminoethyl(meth)acrylate, and 2-dimethylaminopropyl(meth)acrylate.

[0028]

Preferable specific examples of (B1) the carboxyl group-containing copolymer may include:

(meth)acrylic acid/N-phenylmaleimide/styrene/benzyl(meth)acrylate copolymer,
(meth)acrylic acid/N-m-hydroxyphenylmaleimide/styrene/benzyl(meth)acrylate copolymer,
(meth)acrylic acid/N-p-hydroxyphenylmaleimide/styrene/benzyl(meth)acrylate copolymer,
(meth)acrylic acid/N-cyclohexylmaleimide/styrene/benzyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/ α -methylstyrene/benzyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/n-butyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/2-ethylhexyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/p-hydroxy- α -methylstyrene/benzyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/n-butyl(meth)acrylate copolymer,

(meth)acrylic acid/N-phenylmaleimide/styrene/2-ethylhexyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/2-hydroxyethyl(meth)acrylate/benzyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/benzyl(meth)acrylate/glycerol mono(meth)acrylate copolymer,
(meth)acrylic acid/N-p-hydroxyphenylmaleimide/styrene/benzyl(meth)acrylate/glycerol mono(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/phenyl(meth)acrylate/2-hydroxyethyl(meth)acrylate/polystyrene macromonomer copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/phenyl(meth)acrylate/2-hydroxyethyl(meth)acrylate/polymethyl methacrylate macromonomer copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/benzyl(meth)acrylate/n-butyl(meth)acrylate/2-hydroxyethyl(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/benzyl(meth)acrylate/n-butyl(meth)acrylate/glycerol mono(meth)acrylate copolymer,
(meth)acrylic acid/N-phenylmaleimide/styrene/benzyl(meth)acrylate/2-

ethylhexyl (meth)acrylate/2-hydroxyethyl (meth)acrylate
copolymer,

(meth)acrylic acid/N-

phenylmaleimide/styrene/benzyl (meth)acrylate/2-

ethylhexyl (meth)acrylate/glycerol mono(meth)acrylate
copolymer,

[0029]

(meth)acrylic acid/mono[2-(meth)acryloyloxyethyl]

succinate/N-phenylmaleimide/styrene/benzyl (meth)acrylate
copolymer,

(meth)acrylic acid/mono[2-(meth)acryloyloxyethyl]

succinate/N-p-

hydroxyphenylmaleimide/styrene/benzyl (meth)acrylate
copolymer,

(meth)acrylic acid/mono[2-(meth)acryloyloxyethyl]

succinate/N-phenylmaleimide/styrene/allyl (meth)acrylate
copolymer,

(meth)acrylic acid/mono[2-(meth)acryloyloxyethyl]

succinate/N-

cyclohexylmaleimide/styrene/allyl (meth)acrylate copolymer,

(meth)acrylic acid/mono[2-(meth)acryloyloxyethyl]

succinate/N-

cyclohexylmaleimide/styrene/benzyl (meth)acrylate
copolymer,

(meth)acrylic acid/mono[2-(meth)acryloyloxyethyl]

succinate/N-phenylmaleimide/styrene/n-

butyl (meth) acrylate/2-hydroxyethyl (meth) acrylate
copolymer,
(meth) acrylic acid/mono[2-(meth) acryloyloxyethyl]
succinate/N-phenylmaleimide/styrene/n-
butyl (meth) acrylate/glycerol mono(meth) acrylate copolymer,
(meth) acrylic acid/mono[2-(meth) acryloyloxyethyl]
succinate/N-phenylmaleimide/styrene/2-
ethylhexyl (meth) acrylate/2-hydroxyethyl (meth) acrylate
copolymer,
(meth) acrylic acid/mono[2-(meth) acryloyloxyethyl]
succinate/N-phenylmaleimide/styrene/2-
ethylhexyl (meth) acrylate/glycerol mono(meth) acrylate
copolymer,
[0030]
(meth) acrylic acid/ ω -carboxypolycaprolactone
mono(meth) acrylate/N-m-
hydroxyphenylmaleimide/styrene/benzyl (meth) acrylate
copolymer,
(meth) acrylic acid/ ω -carboxypolycaprolactone
mono(meth) acrylate/N-p-
hydroxyphenylmaleimide/styrene/benzyl (meth) acrylate
copolymer,
(meth) acrylic acid/ ω -carboxypolycaprolactone
mono(meth) acrylate/N-
phenylmaleimide/styrene/benzyl (meth) acrylate/glycerol
mono(meth) acrylate copolymer and

(meth)acrylic acid/ ω -carboxypolycaprolactone mono
(meth)acrylate/N-p-
hydroxyphenylmaleimide/styrene/benzyl (meth)acrylate/glyce
rol mono(meth)acrylate copolymer;
(meth)acrylic acid/ ω -carboxypolycaprolactone
mono(meth)acrylate/N-phenylmaleimide/styrene/n-
butyl (meth)acrylate/2-hydroxyethyl (meth)acrylate
copolymer,
(meth)acrylic acid/ ω -carboxypolycaprolactone
mono(meth)acrylate/N-phenylmaleimide/styrene/n-
butyl (meth)acrylate/glycerol mono(meth)acrylate copolymer,
(meth)acrylic acid/ ω -carboxypolycaprolactone
mono(meth)acrylate/N-phenylmaleimide/styrene/2-
ethylhexyl (meth)acrylate/2-hydroxyethyl (meth)acrylate
copolymer,
(meth)acrylic acid/ ω -carboxypolycaprolactone
mono(meth)acrylate/N-phenylmaleimide/styrene/2-
ethylhexyl (meth)acrylate/glycerol mono(meth)acrylate
copolymer.

[0031]

In (B1) the copolymer, the copolymerization ratio of
(meth)acrylic acid is preferably 5 to 30% by weight, and
particularly preferably 10 to 25% by weight; the
copolymerization ratio of the N-substituted maleimide is
preferably 5 to 30% by weight, and particularly
preferably 10 to 25% by weight; the copolymerization
ratio of the unsaturated compound (b3) is preferably 40

to 90% by weight, and particularly preferably 50 to 80% by weight; and the copolymerization ratio of the unsaturated compound (b4) is preferably 0 to 30% by weight, and particularly preferably 0 to 20% by weight.

In the present invention, by setting the copolymerization ratio of each of the unsaturated compounds in (B1) the copolymer to fall within the above range, a radiation-sensitive composition for forming a colored layer that exhibits excellent light transmittance and the developing property can be obtained.

[0032]

In the present invention, (B1) the copolymer may be used in combination with another alkali-soluble resin. Examples of another alkali-soluble resin may include a (meth)acrylic acid/methyl(meth)acrylate copolymer, a (meth)acrylic acid/benzyl(meth)acrylate copolymer, a (meth)acrylic acid/2-hydroxyethyl(meth)acrylate/benzyl(meth)acrylate copolymer, a (meth)acrylic acid/methyl(meth)acrylate/polystyrene macromonomer copolymer, a (meth)acrylic acid/methyl(meth)acrylate/polymethylmethacrylate macromonomer copolymer, a (meth)acrylic acid/benzyl(meth)acrylate/polystyrene macromonomer copolymer,

a (meth)acrylic acid/benzyl(meth)acrylate/polymethylmethacrylate macromonomer copolymer,
a (meth)acrylic acid/2-hydroxyethyl(meth)acrylate/benzyl(meth)acrylate/polystyrene macromonomer copolymer, and
a (meth)acrylic acid/2-hydroxyethyl(meth)acrylate/benzyl(meth)acrylate/polymethylmethacrylate macromonomer copolymer.

[0033]

In the present invention, by reacting (B1) the copolymer, which is a copolymer of an unsaturated compound having a hydroxyl group such as 2-hydroxyethyl(meth)acrylate and/or another alkali-soluble resin with an unsaturated isocyanate compound such as 2-(meth)acryloyloxyethyl isocyanate, a polymerizable unsaturated bond can be introduced into a side chain(s) of (B1) the copolymer and/or another alkali-soluble resin.

[0034]

The weight average molecular weight (hereinafter referred to as "Mw") in terms of polystyrene of (B1) the copolymer and another alkali-soluble resin used in the present invention and measured by gel permeation chromatography (GPC, elution solvent: tetrahydrofuran) is generally 1,000 to 45,000, and preferably 3,000 to 30,000.

Furthermore, the number average molecular weight (hereinafter referred to as "Mn") in terms of polystyrene

of (B1) the copolymer and another alkali-soluble resin used in the present invention measured by gel permeation chromatography (GPC, elution solvent: tetrahydrofuran) is generally 1,000 to 45,000, and preferably 3,000 to 30,000.

In this case, when Mw is less than 1,000, the ratio of the remaining coating decreases, the pattern shape and heat resistance may be damaged and electric properties may deteriorate. On the other hand, where Mw exceeds 45,000, the resolution decreases, the pattern shape may be damaged and dried foreign matters tend to generate when coating is performed by a slit nozzle method.

In the present invention, the alkali-soluble resins may be used alone or as a mixture of two or more thereof.

[0035]

(B1) the copolymer and another type of alkali-soluble resin can be produced by polymerizing, for example, (meth)acrylic acid in an appropriate solvent and in the presence of a radical polymerization initiator such as 2,2'-azobisisobutyronitrile, 2,2'-azobis(2,4-dimethyl valeronitrile) or 2,2'-azobis(4-methoxy-2,4-dimethyl valeronitrile).

[0036]

Furthermore, (B1) the copolymer and another alkali-soluble resin, which is obtained by radical polymerization of the polymerizable unsaturated compound as mentioned above, can be purified by a reprecipitation method by using not less than two organic solvents

different in polarity. To be more specific, purification is performed by subjecting a solution using a good solvent after the polymerization, if necessary, to filtration, centrifugation or the like to remove insoluble impurities and pouring the resultant solution into a large amount of (generally, 5 to 10 fold by volume of the polymer solution) a precipitating agent (poor solvent) to reprecipitate the copolymer. Of the impurities occurred in the polymer solution, those soluble in the precipitating agent are to dissolve in a liquid phase and thus separated from (B1) the copolymer purified, etc.

The combination of the good solvent and the precipitating agent to be used in the reprecipitation method, for example, diethylene glycol monomethyl ether acetate/n-hexane, methyl ethyl ketone/n-hexane, diethylene glycol monomethyl ether acetate/n-heptane, methyl ethyl ketone/n-heptane may be mentioned.

[0037]

Furthermore, (B1) the copolymer and another alkali-soluble resin containing a carboxyl group can be produced, for example, by subjecting each of the unsaturated compounds serving as a constitutional component thereof to living radical polymerization performed 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) and in the presence of a molecular-weight controlling agent serving as an iniferter such as pyrazole-1-dithiocarboxylic acid cyano(dimethyl)methyl ester, pyrazole-1-dithiocarboxylic acid benzyl ester, tetraethylthiuram disulfide, bis(pyrazol-1-ylthiocarbonyl)disulfide, bis(3-methyl-pyrazol-1-ylthiocarbonyl)disulfide, bis(4-methyl-pyrazol-1-ylthiocarbonyl)disulfide, bis(5-methyl-pyrazol-1-ylthiocarbonyl)disulfide, bis(3,4,5-trimethyl-pyrazol-1-ylthiocarbonyl)disulfide, bis(pyrrol-1-ylthiocarbonyl)disulfide or bistiobenzoyl disulfide in an inert solvent at a reaction temperature of generally, 0 to 150°C, preferably 50 to 120°C.

[0038]

In the present invention, (B1) the copolymer may be used alone or as a mixture of two or more thereof. The same is applied to another alkali-soluble resin.

The total amount of the alkali-soluble resins used in the present invention is generally, 10 to 1,000 parts by weight and preferably 20 to 500 parts by weight based on 100 parts by weight of (A) the colorant. In this case, when the total amount of the alkali-soluble resins is less than 10 parts by weight, the developing property with alkali may decrease and film residue and scum may occur on the unexposed portions of a substrate or a light-shielding layer. On the other hand, when the amount exceeds 1,000 parts by weight, the content of the

colorant relatively decreases. As a result, it may be difficult to attain a color density desired as a thin film.

Furthermore, the total ratio of (B1) the copolymer used in the alkali-soluble resin is preferably 10 to 100% by weight, and particularly preferably 30 to 100% by weight. In this case, when the ratio of (B1) the copolymer is less than 10% by weight, the desired effect of the present invention may not be obtained.

[0039]

- (C) Polyfunctional Monomer -

The polyfunctional monomer of the present invention is a monomer having not less than two polymerizable unsaturated bonds.

Examples of the polyfunctional monomer may include di(meth)acrylates of alkylene glycols such as ethylene glycol and propylene glycol; di(meth)acrylates of polyalkylene glycols such as polyethylene glycol equal to or larger than diethylene glycol, a polypropylene glycol equal to or larger than dipropylene glycol; poly(meth)acrylates of tri or more valent polyhydric alcohols such as glycerin, trimethylolpropane, pentaerythritol and dipentaerythritol, and modified dicarboxylic acids thereof;

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

di(meth)acrylates of a polymer having hydroxyl groups at both ends such as a poly-1,3-butadiene having hydroxyl groups at both ends, a polyisoprene having hydroxyl groups at both ends and a polycaprolactone having hydroxyl groups at both ends, and tris[2-(meth)acryloyloxyethyl]phosphate.

[0040]

Of these polyfunctional monomers, the poly(meth)acrylates of the tri or more valent polyhydric alcohols and the modified dicarboxylic acids thereof are preferred. Specific preferable examples may include trimethylolpropane tri(meth)acrylate, pentaerythritol tri(meth)acrylate, pentaerythritol tetra(meth)acrylate, dipentaerythritol penta(meth)acrylate and dipentaerythritol hexa(meth)acrylate. Of them, particularly, trimethylolpropane triacrylate, pentaerythritol triacrylate and dipentaerythritol hexaacrylate are preferable since the intensity of the resultant pixels is high and the surface of the pixels is smooth, and scum and film residue may rarely occur on the unexposed portions of a substrate and a light-shielding layer.

The polyfunctional monomers as mentioned above may be used alone or as a mixture of two or more thereof.

[0041]

The amount of the polyfunctional monomer used in the present invention is generally, 5 to 500 parts by weight and preferably 20 to 300 parts by weight based on 100 parts by weight of (B) the alkali-soluble resin. In this case, when the amount of the polyfunctional monomer is less than 5 parts by weight, the intensity of the pixels and the surface smoothness thereof tend to decrease. On the other hand, when the amount exceeds 500 parts by weight, for example, the developing property with alkali may decrease and scumming and film residue tend to occur on the unexposed portions of a substrate and a light-shielding layer.

[0042]

In the present invention, a polyfunctional monomer may be partly substituted with a monofunctional monomer having a single polymerizable unsaturated bond.

As the monofunctional monomer, for example, those exemplified with respect to (B) the alkali-soluble resin mentioned above may be mentioned. Specific examples may include unsaturated carboxyl group-containing monomers, copolymerizable unsaturated monomers and N-vinyl nitrogen-containing heterocyclic compounds such as N-vinylsuccinimide, N-vinylpyrrolidone, N-vinylphthalimide, N-vinyl-2-piperidone, N-vinyl- ϵ -caprolactam, N-vinylpyrrole, N-vinylpyrrolidine, N-vinylimidazole, N-vinylimidazolidine, N-vinylindole, N-vinylindoline, N-

vinylbenzimidazole, N-vinylcarbazole, N-vinylpiperidine, N-vinylpiperazine, N-vinylmorpholine and N-vinylphenoxadine; and N-(meth)acryloylmorpholine. Besides these, commercially available products such as M-5300, M-5400 and M-5600 (trade names, manufactured by Toagosei Co., Ltd.) may be mentioned.

These monofunctional monomers may be used alone or as a mixture of two or more thereof.

[0043]

The ratio of the monofunctional monomer is generally not more than 90% by weight and preferably not more than 50% by weight based on the total amount of the polyfunctional monomer and the monofunctional monomer. In this case, when the ratio of the monofunctional monomer exceeds 90% by weight, the intensity of the resultant pixels and the surface smoothness thereof tend to decrease.

[0044]

- (D) Photopolymerization Initiator -

The photopolymerization initiator of the present invention is a compound which generates a radical capable of starting the polymerization of (C) the polyfunctional monomer by exposure to radiation such as visible rays, ultraviolet rays, far-ultraviolet rays, electron beams or X-rays.

Examples of the photopolymerization initiator include acetophenone compounds, biimidazole compounds,

triazine compounds, O-acyloxime compounds, onium salt compounds, benzoin compounds, benzophenone compounds, α -diketone compounds, multinuclear quinone compounds, xanthone compounds, diazo compounds and imidosulfonate compounds.

[0045]

The photopolymerization initiators in the present invention can be used alone or as a mixture of two or more thereof. As the photopolymerization initiator to be used in the present invention, at least one selected from the group consisting of the acetophenone compounds, the biimidazole compounds, the triazine compounds and the O-acyloxime compounds is preferred.

[0046]

In the present invention, the general amount of the photopolymerization initiator is generally, 0.01 to 120 parts by weight and preferably 1 to 100 parts by weight based on 100 parts by weight of the total of (C) the polyfunctional monomer and the monofunctional monomer. In this case, when the amount of photopolymerization initiator is less than 0.01 part by weight, curing by exposure becomes insufficient. As a result, a color filter in which a pattern on the colored layer is arranged in accordance with a predetermined array may not be obtained. On the other hand, when the amount exceeds 120 parts by weight, the formed colored layer tends to peel off from a substrate during a developing process.

[0047]

Of the preferable photopolymerization initiators in the present invention, specific examples of the acetophenone compounds may include 2-hydroxy-2-methyl-1-phenylpropan-1-one, 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one, 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one, 1-hydroxycyclohexyl-phenyl ketone, 2,2-dimethoxy-1,2-diphenylethane-1-one, and 1,2-octane dione.

Of these acetophenone compounds, particularly, 2-methyl-1-[4-(methylthio)phenyl]-2-morpholinopropan-1-one, 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one, and 1,2-octanedione are preferred.

The above acetophenone compounds can be used alone or as a mixture of two or more thereof.

[0048]

In the present invention, when the acetophenone compound is used as the photopolymerization initiator, the amount thereof is generally, 0.01 to 80 parts by weight, preferably 1 to 70 parts by weight, and more preferably 1 to 60 parts by weight based on 100 parts by weight of the total of (C) the polyfunctional monomer and the monofunctional monomer. In this case, when the amount of acetophenone compound is less than 0.01 part by weight, curing by exposure becomes insufficient. As a result, a color filter in which a pattern on the colored layer is arranged in accordance with a predetermined

array may not be obtained. On the other hand, when the amount exceeds 80 parts by weight, the formed colored layer tends to peel off from a substrate during a developing process.

[0049]

Further, specific examples of the biimidazole compound may 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.

[0050]

Of these biimidazole 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-trichlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole are preferred. Particularly, 2,2'-bis(2-chlorophenyl)-4,4',5,5'-tetraphenyl-1,2'-biimidazole is preferred.

These biimidazole compounds are excellent in solubility in a solvent and free from generation of foreign substances such as insoluble matters and precipitation. In addition, since they have high sensitivity, a curing reaction can sufficiently proceed by exposure in a small amount of energy and no curing reaction occurs in unexposed portions. Therefore, in the coating after exposure, cured portions insoluble in a developer can be distinguishably divided from uncured portions highly soluble in the developer. In this way, a high-definition color filter in which a colored layer pattern having no undercut is arranged in accordance with a predetermined array can be formed.

The biimidazole compounds can be used alone or as a mixture of two or more thereof.

[0051]

In the present invention, when the biimidazole compound is used as the photopolymerization initiator, the amount thereof is generally, 0.01 to 40 parts by weight, preferably 1 to 30 parts by weight, and more preferably 1 to 20 parts by weight based on 100 parts by weight of the total of (C) the polyfunctional monomer and the monofunctional monomer. In this case, when the amount of biimidazole compound is less than 0.01 part by weight, curing by exposure becomes insufficient. As a result, a color filter in which a pattern on the colored layer is arranged in accordance with a predetermined

array may not be obtained. On the other hand, when the amount exceeds 40 parts by weight, the formed colored layer tends to peel off from a substrate and the surface of a colored layer tends to be roughened during a developing process.

[0052]

In the present invention, when the biimidazole compound is used as the photopolymerization initiator, a hydrogen donor as described below is preferably used in combination because it can further improve the sensitivity.

The term "hydrogen donor" as used herein refers to a compound which can donate a hydrogen atom to a radical generated from the biimidazole compound by exposure.

As the hydrogen donor in the present invention, mercaptan compounds and amine compounds etc., defined below are preferred.

[0053]

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

The above amine compound is a compound which has a benzene ring or a heterocyclic ring as a mother nucleus and one or more, preferably 1 to 3 and more preferably 1

to 2 amino groups which are directly bound to the mother nucleus (hereinafter, referred to as the "amine hydrogen donor").

It is to be noted that these hydrogen donors also may have a mercapto group and an amino group at the same time.

[0054]

The hydrogen donor will be more specifically described below.

The mercaptan hydrogen donor can have one or more benzene rings or heterocyclic rings, and can have both thereof. When the donor has two or more of these rings, a fused ring may be formed or not.

In addition, when the mercaptan hydrogen donor has two or more mercapto groups, as long as at least one free mercapto group remains, one or more remaining mercapto groups may be substituted with an alkyl, aralkyl or aryl group. Furthermore, as long as at least one free mercapto group remains, the donor may have a structural unit in which two sulfur atoms are bound to each other through a divalent organic group such as an alkylene group or a structural unit in which two sulfur atoms are bound to each other to form a disulfide bond.

Furthermore, the mercaptan hydrogen donor may be substituted at a position other than a mercapto group, with a carboxyl group, an alkoxycarbonyl group, a substituted alkoxycarbonyl group, a phenoxycarbonyl group,

a substituted phenoxy carbonyl group, a nitrile group or the like.

[0055]

Specific examples of the mercaptan hydrogen donor include 2-mercaptobenzothiazole, 2-mercaptobenzoxazole, 2-mercaptobenzimidazole, 2,5-dimercapto-1,3,4-thiadiazole and 2-mercapto-2,5-dimethylaminopyridine.

Of these mercaptan hydrogen donors, 2-mercaptobenzothiazole and 2-mercaptobenzoxazole are preferred, and 2-mercaptobenzothiazole is particularly preferred.

[0056]

Further, the amine hydrogen donor can have one or more benzene rings or heterocyclic rings, and can have both thereof, and when the donor has two or more of these rings, a fused ring may be formed or not.

Furthermore, in the amine hydrogen donor, one or more of amino groups may be substituted with an alkyl group or a substituted alkyl group. Alternatively, the amine hydrogen donor may be substituted at a position other than an amino group with a carboxyl group, an alkoxycarbonyl group, a substituted alkoxycarbonyl group, a phenoxy carbonyl group, a substituted phenoxy carbonyl group, a nitrile group or the like.

[0057]

Specific examples of the amine hydrogen donor may include 4,4'-bis(dimethylamino)benzophenone, 4,4'-

bis(diethylamino)benzophenone, 4-diethylaminoacetophenone, 4-dimethylaminopropiophenone, ethyl 4-dimethylaminobenzoate, 4-dimethylaminobenzoic acid and 4-dimethylaminobenzonitrile.

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

It is to be noted that the amine hydrogen donor has a function as a sensitizer also when a photopolymerization initiator other than the biimidazole compound is used.

[0058]

In the present invention, the hydrogen donor can be used alone or as a mixture of two or more thereof. However, at least one mercaptan hydrogen donor and at least one amine hydrogen donor are preferably used in combination. This is because the formed colored layer is unlikely to peel off from a substrate during a developing process and the strength and the sensitivity of the colored layer are high.

Specific examples of the combination of the mercaptan hydrogen donor and the amine hydrogen donor may include 2-mercaptobenzothiazole/4,4'-bis(dimethylamino)benzophenone, 2-mercaptobenzothiazole/4,4'-bis(diethylamino)benzophenone, 2-mercaptobenzoxazole/4,4'-bis(dimethylamino)benzophenone

and 2-mercaptobenzoxazole/4,4'-bis(diethylamino)benzophenone. More preferable combinations are 2-mercaptobenzothiazole/4,4'-bis(diethylamino)benzophenone and 2-mercaptobenzoxazole/4,4'-bis(diethylamino)benzophenone. Particularly preferable combination is 2-mercaptobenzothiazole/4,4'-bis(diethylamino)benzophenone.

In the combination of the mercaptan hydrogen donor and the amine hydrogen donor, the mass ratio of the mercaptan hydrogen donor to the amine hydrogen donor is generally 1:1 to 1:4, and preferably 1:1 to 1:3.

[0059]

In the present invention, when a hydrogen donor is used in combination with the biimidazole compound, the amount thereof 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 based on 100 parts by weight of the total of (C) the polyfunctional monomer and the monofunctional monomer. In this case, when the amount of the hydrogen donor is less than 0.01 part by weight, the effect of improving the sensitivity tends to decrease. On the other hand, when the amount exceeds 40 parts by weight, the formed colored layer tends to peel off from a substrate during a developing process.

[0060]

Note that when the amine hydrogen donor is used in combination with the photopolymerization initiator except

a biimidazole compound such as an acetophenone compound, it can serve as a sensitizer. When the amine hydrogen donor is used as a sensitizer, the amount thereof is generally not more than 300 parts by weight, preferably not more than 200 parts by weight and more preferably not more than 100 parts by weight based on 100 parts by weight of the photopolymerization initiator except the biimidazole compound. When the amount is excessively low, sufficient effect cannot be obtained. Therefore, it is desirable that the lower limit of the amount is set at preferably 2 parts by weight, and more preferably 5 parts by weight.

[0061]

Further, specific examples of the triazine compounds may include triazine 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.

[0062]

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

The triazine compounds can be used alone or as a mixture of two or more thereof.

[0063]

In the present invention, when the triazine compound is used as the photopolymerization initiator, the amount 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 based on 100 parts by weight of the total of (C) the polyfunctional monomer and the monofunctional monomer. In this case, when the amount of triazine compound is less than 0.01 part by weight, curing by exposure becomes insufficient. As a result, a color filter in which a pattern on the colored layer is arranged in accordance with a predetermined array may not be obtained. On the other hand, when the amount exceeds 40 parts by weight, the formed colored layer tends to peel off from the substrate during a developing process.

[0064]

Specific examples of the O-acyloxime compound may include 1,2-heptanedione, 1-[4-(phenylthio)phenyl]-, 2-(O-benzoyloxime); 1,2-octanedione, 1-[4-(phenylthio)phenyl]-, 2-(O-benzoyloxime); 1,2-octanedione, 1-[4-(benzoyl)phenyl]-, 2-(O-benzoyl oxime); ethanone, 1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-, 1-(O-

acetyloxime); ethanone, 1-[9-ethyl-6-(3-methylbenzoyl)-9H-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-(9-ethyl-6-benzoyl-9H-carbazol-3-yl)-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-4-tetrahydrofuranylbzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-4-tetrahydropyranylbzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-5-tetrahydrofuranylbzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-5-tetrahydropyranylbzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-{2-methyl-4-(2,2-dimethyl-1,3-dioxolanyl)benzoyl}-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-4-tetrahydrofuranylmethoxybenzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-4-tetrahydropyranylmethoxybenzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-5-tetrahydrofuranylmethoxybenzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-5-tetrahydropyranylmethoxybenzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); and ethanone, 1-[9-ethyl-6-{2-methyl-4-(2,2-dimethyl-1,3-dioxolanyl)methoxybenzoyl}-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime).

[0065]

Of these O-acyloxime compounds, particularly, 1,2-octanedione, 1-[4-(phenylthio)phenyl]-, 2-(O-

benzoyloxime); ethanone, 1-[9-ethyl-6-(2-methylbenzoyl)-9H-carbazol-3-yl]-, 1-(O-acetyloxime); ethanone, 1-[9-ethyl-6-(2-methyl-4-tetrahydrofuranylmethoxybenzoyl)-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime); and ethanone, 1-[9-ethyl-6-{2-methyl-4-(2,2-dimethyl-1,3-dioxolanyl)methoxybenzoyl}-9.H.-carbazol-3-yl]-, 1-(O-acetyloxime) are preferred.

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

[0066]

In the present invention, when the O-acyloxime compound is used as the photopolymerization initiator, the amount thereof is preferably 0.01 to 60 parts by weight, more preferably 1 to 50 parts by weight, and particularly preferably 1 to 40 parts by weight based on 100 parts by weight of the total of (C) the polyfunctional monomer and the monofunctional monomer. In this case, when the amount of the O-acyloxime compound is less than 0.01 part by weight, curing by exposure becomes insufficient. As a result, a color filter in which a pattern on a colored layer is arranged in accordance with a predetermined array may not be obtained. On the other hand, when the amount exceeds 60 parts by weight, the formed colored layer tends to peel off from the substrate during a developing process.

[0067]

- Other additives -

The radiation-sensitive composition of the present invention contains the aforementioned components (A) to (D); however, other additives may be contained, as needed.

Examples of other additives mentioned above may include fillers such as glass and alumina; macromolecule compounds such as polyvinyl alcohol, and poly(fluoroalkylacrylate); surfactants such as nonionic, cationic and anionic surfactants; adhesion promoters such as vinyltrimethoxysilane, vinyltriethoxysilane, vinyltris(2-methoxyethoxy)silane, N-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane, N-(2-aminoethyl)-3-aminopropyltrimethoxysilane, 3-aminopropyltriethoxysilane, 3-glycidoxypropyltrimethoxysilane, 3-glycidoxypropylmethyldimethoxysilane, 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, 3-chloropropylmethyldimethoxysilane, 3-chloropropyltrimethoxysilane, 3-methacryloyloxypropyltrimethoxysilane and 3-mercaptopropyltrimethoxysilane; 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 alkoxybenzophenone; and aggregation inhibitors such as sodium polyacrylate.

[0068]

Solvent

The radiation-sensitive composition of the present invention contains the aforementioned components (A) to

(D), and optional other additives and is generally prepared as a liquid composition by adding a solvent thereto.

As the solvent, any solvent can be appropriately selected and put in use as long as it can disperse or dissolve the components (A) to (D) constituting the radiation-sensitive composition and other additive components and as long as it does not react with these components and has a proper volatility.

[0069]

Examples of the solvent may include alcohols such as methanol, ethanol and benzyl alcohol; (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, 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;

[0070]

(poly)alkylene glycol monoalkyl ether acetates such as ethylene glycol monomethyl ether acetate, ethylene glycol monoethyl ether acetate, ethylene glycol mono-n-propyl ether acetate, ethylene glycol mono-n-butyl ether acetate, diethylene glycol monomethyl ether acetate, diethylene glycol monoethyl ether acetate, diethylene glycol mono-n-propyl ether acetate, diethylene glycol mono-n-butyl 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, 3-heptanone, diacetone alcohol (4-hydroxy-4-methylpentan-2-one) and 4-hydroxy-4-methylhexan-2-one;

[0071]

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

other esters such as ethyl acetate, n-propyl acetate, i-propyl acetate, n-butyl acetate, i-butyl acetate, n-pentyl formate, i-pentyl acetate, 3-methoxybutyl acetate, 3-methyl-3-methoxybutyl acetate, n-butyl propionate, 3-methoxybutyl acetate, 3-methyl-3-methoxybutyl propionate, ethyl butyrate, n-propyl butyrate, i-propyl butyrate, n-butyl butyrate, ethyl hydroxyacetate, ethyl ethoxyacetate, methyl 3-methoxypropionate, ethyl 3-methoxypropionate,

methyl 3-ethoxypropionate, ethyl 3-ethoxypropionate, methyl pyruvate, ethyl pyruvate, n-propyl pyruvate, methyl acetoacetate, ethyl acetoacetate, ethyl 2-hydroxy-2-methylpropionate, methyl 2-hydroxy-3-methylbutyrate and ethyl 2-oxobutyrate; aromatic hydrocarbons such as toluene and xylene; and amides such as N-methylpyrrolidone, N,N-dimethylformamide, and N,N-dimethylacetamide.

[0072]

Of these solvents, from the viewpoints of the solubility, the pigment dispersibility and the applicability etc., benzyl alcohol, ethylene glycol mono-n-butyl ether, propylene glycol monomethyl ether, propylene glycol monoethyl ether, ethylene glycol monomethyl ether acetate, ethylene glycol mono-n-butyl ether acetate, diethylene glycol mono-n-butyl ether acetate, propylene glycol monomethyl ether acetate, propylene glycol monoethyl ether acetate, diethylene glycol dimethyl ether, diethylene glycol methyl ethyl ether, cyclohexanone, 2-heptanone, 3-heptanone, n-butyl acetate, i-butyl acetate, n-pentyl formate, i-pentyl acetate, 3-methoxybutyl acetate, n-butyl propionate, ethyl butyrate, i-propyl butyrate, n-butyl butyrate, ethyl 3-methoxypropionate, methyl 3-ethoxypropionate, ethyl 3-ethoxypropionate, 3-methoxybutyl acetate, 3-methyl-3-methoxybutyl propionate, and ethyl pyruvate are preferred.

The solvents mentioned above may be used alone or as a mixture of two or more thereof.

[0073]

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

These high-boiling point solvents can be used alone or as a mixture of two or more thereof.

[0074]

The amount of the solvent is not particularly limited; however, from the viewpoints of the applicability and the storage stability of the resultant radiation-sensitive composition, it is desirable that the total concentration of the components of the composition excluding a solvent is preferably 5 to 50% by weight and more preferably 10 to 40% by weight.

[0075]

A Method for Forming Color Filter

Next, a method for forming the color filter of the present invention using the radiation-sensitive composition of the present invention will be described.

The method for forming the color filter generally includes at least the following (1) to (4) steps.

(1) a step of forming a coating of the radiation-sensitive composition of the present invention on a substrate;

(2) a step of exposing at least a part of the coating to light;

(3) a step of developing the coating after the exposure step; and

(4) a step of post-baking the coating after the developing step

Now, these steps will be explained in order.

[0076]

- Step (1) -

At first, a light-shielding layer is formed on the surface of a substrate to section the parts to form pixels as required, and the radiation-sensitive composition of the present invention containing (A) the pigment in red and prepared generally in liquid form, is applied onto this substrate. Then, the substrate is subjected to pre-baking to evaporate and remove a solvent to form a coating.

Examples of materials of the substrate to be used in this step may include glass, silicon, polycarbonates, polyesters, aromatic polyamides, polyamide-imides, polyimides, polyethersulfones and other compounds such as

ring-opened polymers of cyclic olefins and hydrogenated substances thereof.

In addition, the substrate, if desired, may be previously and appropriately treated with a chemical such as a silane coupling agent or treated by plasma, ion plating, sputtering, a gas phase reaction or vacuum deposition.

In applying the liquid composition to the substrate, an appropriate coating method such as a rotary coating method, flow casting coating method, a roll coat method or a slit die coating method can be employed. However, the rotary coating method and the slit die coating method are preferred.

The pre-baking is generally performed under the conditions of at 70 to 110°C for about 2 to 4 minutes.

The coating thickness, which is measured as the film thickness after the solvent is removed, is generally 1.0 to 10 μm , preferably, 1.0 to 6.0 μm and particularly preferably 1.0 to 4.0 μm .

[0077]

- Step (2) -

Then, at least a part of the formed coating is exposed to radiation. In this case, when a part of the coating is exposed to radiation, it is generally exposed through a photomask having a predetermined pattern.

Examples of the radiation to be used in this step may include visible rays, ultraviolet rays, far-

ultraviolet rays, electron beams and X-rays, but radiation having a wavelength within the range of 190 to 450 nm is preferred.

The exposure dose of the radiation is generally about 10 to 10,000 J/m².

[0078]

- Step (3) -

Then, the exposed coating is developed with a developer, preferably, an alkaline developer. Unexposed portions of the coating are dissolved and removed.

As the alkaline developer, for example, aqueous solutions of compounds such as sodium carbonate, sodium hydroxide, potassium hydroxide, tetramethylammonium hydroxide, choline, 1,8-diazabicyclo-[5.4.0]-7-undecene or 1,5-diazabicyclo-[4.3.0]-5-nonene are preferred.

To the alkaline developer, for example, a water-miscible organic solvent such as methanol or ethanol and a surfactant, etc., can be added in an appropriate amount. It is to be noted that the coating is generally rinsed with water after a developing process with the alkali.

As a developing process, a shower developing method, a spray developing method, a dip (immersion) developing method, and a puddle developing method can be applied. The developing process is preferably performed at an ordinary temperature for about 10 to 300 seconds.

[0079]

- Step (4) -

Then, the coating after the developing process is subjected to post-baking to obtain the substrate in which a red pixel pattern formed by using the cured radiation-sensitive composition is arranged in a predetermined array.

The post-baking is preferably performed in the conditions of 180 to 230°C for about 20 to 40 minutes.

The film thickness of the pixels thus formed is generally 0.5 to 5.0 μm and preferably 1.0 to 3.0 μm .

[0080]

Further, the above steps (1) to (4) steps are repeated by using a green radiation-sensitive composition containing (A) a green pigment to form a green pixel pattern on the same substrate. Also, the above steps (1) to (4) steps are repeated by using a blue radiation-sensitive composition containing (A) a blue pigment to form a blue pixel pattern on the same substrate. In this way, pixel arrays in which pixel patterns of the three primary colors (red, green and blue) are arranged in predetermined arrays can be formed on the substrate. However, the order of forming pixel patterns of individual colors in the present invention is not limited to the above order.

[0081]

Color Filter

The color filter of the present invention has red pixels formed of the radiation-sensitive composition for forming the red color filter of the present invention.

The color filter of the present invention is extremely useful for use in, for example, liquid crystal display devices having a wide color reproduction area represented by TV.

[0082]

Color Liquid Crystal Display Device

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

The color liquid crystal display device of the present invention may have an appropriate structure, for example, a structure formed by forming a color filter on a different substrate from a driving substrate having a thin film transistor (TFT) disposed thereon and arranging the driving substrate and the substrate having the color filter formed thereon to face each other with a liquid crystal layer interposed between them, and a structure formed by arranging the driving substrate having a thin film transistor (TFT) disposed thereon and further a color filter formed on the surface thereof and a substrate having an ITO (indium oxide doped with tin) electrode formed thereon so as to face each other with a liquid crystal layer interposed between them. The structure of the latter one has an advantage in that the

numerical aperture can be significantly improved and therefore a bright and high definition color liquid crystal display device can be obtained.

[0083]

The radiation-sensitive composition for the red color filter of the present invention is capable of forming red pixels having high light transmittance and high chromatic purity without increasing the film thickness of a coating and the content of a pigment component in the radiation-sensitive composition.

Accordingly, the radiation-sensitive composition of the present invention is extremely suitable for manufacturing various color filters including color filters for color liquid crystal display devices and color-resolution color filter for solid-state imaging sensing devices in the field of electronics industry.

[Examples]

[0084]

Hereinafter, the embodiments of the present invention will be more specifically described by way of Examples. However, the present invention is not limited to the Examples below.

Preparation of Pigment Dispersion Solution

Preparation Example 1

C.I. pigment red 166 (13.5 parts by weight) and C.I. pigment red 254 (1.5 parts by weight) serving as (A) the colorant, 5 parts by weight of AJISPER PB 822

(manufactured by Ajinomoto Fine-Techno Co., Inc.) serving as the dispersant, and 80 parts by weight of propylene glycol monomethyl ether acetate serving as a solvent were mixed and dispersed by a beads mill for 12 hours to prepare a pigment dispersion solution (M-1).

[0085]

Preparation Examples 2 to 12

Pigment dispersion solutions (M-2) to (M-12) were prepared in the same manner as in Preparation Example 1 except that the colorants of Preparation Example 1 were changed to those shown in Table 1.

[0086]

[Table 1]

	Name	R166	R224	R242	R254	O38	O71	Y83	Y138	Y139	Y150
Preparation Example 1	M-1	13.50			1.50						
Preparation Example 2	M-2	7.50	1.80							5.70	
Preparation Example 3	M-3	7.50		6.60	0.90						
Preparation Example 4	M-4	7.50			2.25	5.25					
Preparation Example 5	M-5	7.50			3.00		4.50				
Preparation Example 6	M-6	7.50			4.20			3.30			
Preparation Example 7	M-7	7.50			6.00				1.50		
Preparation Example 8	M-8	7.50			4.50					3.00	
Preparation Example 9	M-9	7.50			5.70						1.80
Preparation Example 10	M-10			12.75	2.25						
Preparation Example 11	M-11		9.75							5.25	
Preparation Example 12	M-12				3.75	11.25					

[0087]

In Table 1, for example, "R166" represents C.I. pigment red 166, "O38" represents C.I. pigment orange 38; "Y83" represents C.I. pigment yellow 83, respectively.

[0088]

(B) Synthesis of Alkali-soluble Resin

Synthesis Example 1

A flask equipped with a condenser and a stirrer was charged with 2 parts by weight of 2,2'-azobisisobutyronitrile and 200 parts by weight of propylene glycol monomethyl ether acetate, and subsequently, with 15 parts by weight of methacrylic acid, 20 parts by weight of N-phenylmaleimide, 55 parts by weight of benzyl methacrylate, 10 parts by weight of styrene, and 3 parts of 2,4-diphenyl-4-methyl-1-pentene (trade name: Nofmer MSD, manufactured by NOF CORPORATION) serving as a molecular-weight controlling agent and purged with nitrogen gas. Thereafter, the reaction solution was gently stirred while increasing the temperature thereof to 80°C. Polymerization was performed by maintaining the solution at this temperature for 5 hours to obtain a resin solution (solid content concentration: 33.3% by weight). The Mw of the obtained resin was 16,000 and Mn was 7,000. This resin solution was referred to as "resin solution (B-1)".

[0089]

Example 1

100 parts by weight of the pigment dispersion solution (M-1) as (A) the colorant, 10 parts by weight (in terms of solid content) of (B-1) the resin solution as (B) the alkali-soluble resin, 15 parts by weight of

dipentaerythritol hexaacrylate as (C) the polyfunctional monomer, 4 parts by weight of 2-benzyl-2-dimethylamino-1-(4-morpholinophenyl)butane-1-one and 1 part by weight of 4'-bis(diethylamino)benzophenone as (D) the photopolymerization initiator, and propylene glycol monomethyl ether acetate as a solvent were mixed to prepare a liquid composition (R-1) having a solid-content concentration of 25%.

The liquid composition (R-1) was processed in accordance with the following procedure to form a pixel pattern and evaluated. The evaluation results are shown in Table 2.

[0090]

Pattern Formation

The liquid composition (R-1) was applied by a spin coater with its rotation number varied onto the surface of three soda glass substrates having a SiO₂ film for preventing sodium ions from being eluted on the surface. The thus obtained substrates were subjected to pre-baking at 90°C for 4 minutes by using a hot plate to form three coatings different in thickness thereon.

Subsequently, each of the three substrates thus prepared was cooled to room temperature and was exposed to radiation at an exposure dose of 400 J/m² having wavelengths of 365 nm, 405 nm and 436 nm through a photomask by using a high-pressure mercury lamp. Thereafter, these substrates were sprayed with a

developer of a 0.04 wt% aqueous potassium hydroxide solution controlled at 23°C through a nozzle (1 mm in diameter) at a developing pressure of 1 kgf/cm². After the shower development, post-baking was performed at 220°C for 30 minutes to form a red-dot pattern in an area of 200 × 200 μm on the substrate.

[0091]

Evaluation of Chromaticity and Film Thickness

The red-dot pattern thus obtained was measured for chromaticity coordinates (x, y) in the CIE color coordinate system and brightness (Y value) by a color analyzer (MCPD 2000 manufactured by Otsuka Electronics Co., Ltd.) using a C light source in two fields of vision. Furthermore, the film thickness of the obtained red-dot pattern was measured by α-step IQ manufactured by KLA-Tencor Corporation. Based on the measurement results, the chromaticity coordinate (y), brightness (Y value) and film thickness when the coordinate x takes 0.603 were obtained. The evaluation results are shown in Table 2. Table 2 shows that the larger the Y value, the higher the light transmittance (brightness), and the thinner the film thickness, the larger the coloring ability.

[0092]

Evaluation of Solvent Resistance

Each of the aforementioned three substrates having a red-dot pattern formed thereon was soaked in N-methylpyrrolidone at 25°C for 30 minutes. The dot

pattern before and after the soaking was observed by a scanning electron microscope. Evaluation was performed by giving A in the case where a pattern having a satisfactory edge shape is formed and a film thickness ratio before and after soaking (the film thickness after soaking $\times$ 100/the film thickness before soaking) is 95% or more, giving B in the case where the film thickness ratio before and after soaking is less than 95% or a defective part is observed in the pattern, and giving C in the case where a pattern is completely removed from the substrate after soaking.

[0093]

Examples 2 to 9 and Comparative Examples 1 to 3

Liquid compositions (R-2) to (R-12) were prepared in the same manner as in Example 1 except that the pigment dispersion solution of Example 1 was changed to those shown in Table 2.

Evaluation was performed in the same manner as in Example 1 except that liquid compositions (R-2) to (R-12) were used in place of the liquid composition (R-1). The evaluation results are shown in Table 2.

[0094]

[Table 2]

	Pigment dispersion solution	x	y	Y value	Film thickness (μm)	Solvent resistance
Example 1	M-1	0.603	0.359	31.0	1.26	A
Example 2	M-2	0.603	0.359	30.7	1.20	A
Example 3	M-3	0.603	0.359	31.0	1.30	A
Example 4	M-4	0.603	0.359	30.8	1.32	A
Example 5	M-5	0.603	0.359	30.8	1.22	A
Example 6	M-6	0.603	0.359	30.6	1.35	A
Example 7	M-7	0.603	0.359	30.5	1.21	A
Example 8	M-8	0.603	0.359	30.6	1.18	A
Example 9	M-9	0.603	0.359	30.5	1.23	A
Comparative Example 1	M-10	0.603	0.359	31.1	1.41	C
Comparative Example 2	M-11	0.603	0.359	29.7	1.00	B
Comparative Example 3	M-12	0.603	0.359	30.5	1.55	C

[0095]

As is apparent from Table 2, by using C.I. pigment red 166 in combination with at least one pigment selected from the group consisting of C.I. pigment red 224, 242 and 254, red pixels having a good light transmittance (brightness) and good chromatic purity can be formed. In addition, it is found that solvent resistance can be improved by introducing C.I. pigment red 166. This is because the dispersion stability is improved by dispersing C.I. pigment red 166 together with other pigment(s).

What is claimed is:

1. A radiation-sensitive composition for a red color filter, which is a radiation-sensitive composition for forming a colored layer comprising (A) a colorant, (B) an alkaline soluble resin, (C) a polyfunctional monomer and (D) a photopolymerization initiator, wherein (A) the colorant comprises (A1) C.I. pigment red 166 and (A2) at least one pigment selected from the group consisting of C.I. pigment red 224, C.I. pigment red 242 and C.I. pigment red 254.
2. The radiation-sensitive composition for a red color filter according to claim 1, further comprising at least one of a yellow organic pigment and an orange organic pigment as (A) the colorant.
3. The radiation-sensitive composition for the red color filter according to claim 2, comprising at least one pigment selected from the group consisting of C.I. pigment orange 38, C.I. pigment orange 71, C.I. pigment yellow 83, C.I. pigment yellow 138, C.I. pigment yellow 139 and C.I. pigment yellow 150 as (A) the colorant.
4. The radiation-sensitive composition for the red color filter according to any one of claims 1 to 3, wherein a content of (A1) is 20 to 95% by weight, and a

content of (A2) is 1 to 80% by weight based on the total weight of (A) the cololant.

5. A color filter comprising a red color filter formed by using the radiation-sensitive composition according to any one of claims 1 to 4.

6. A color liquid crystal display device comprising the color filter according to claim 5.