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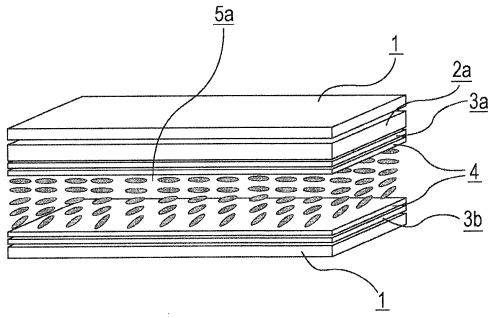
(54) LIQUID CRYSTAL DISPLAY DEVICE

(57) The present invention relates to a liquid crystal display apparatus including a specific liquid crystal composition and a color filter including a specific pigment. The present invention provides a liquid crystal display apparatus that may limit a reduction in the voltage holding ratio (VHR) of a liquid crystal layer and limit an increase in the ion density (ID) in the liquid crystal layer and address issues of faulty display such as white missing pixels, alignment inconsistencies, and burn-in. Having a feature of limiting a reduction in the voltage holding ratio (VHR) of a liquid crystal layer and limiting an increase in an ion density (ID) in the liquid crystal layer and thereby reducing occurrence of faulty display such as burn-in, the liquid crystal display apparatus according to the present invention may be particularly suitably used as a VA-mode or PSVA-mode liquid crystal display apparatus for active-matrix driving and may be used as a liquid crystal display apparatus included in a liquid crystal TV, a monitor, a mobile phone, a smart phone, or the like.

FIG. 2



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Description

Technical Field

[0001] The present invention relates to a liquid crystal display apparatus.

Background Art

[0002] Liquid crystal display apparatuses have been widely used in clocks, electronic calculators, various home appliances, measuring equipment, panels for automobiles, word processors, electronic personal organizers, printers, computers, TVs, and the like. Common examples of liquid crystal display methods include a TN (twisted nematic) type, a STN (super-twisted nematic) type, a DS (dynamic light scattering) type, a GH (guest-host) type, an IPS (in-plane switching) type, an OCB (optically compensated birefringence) type, an ECB (electrically controlled birefringence) type, a VA (vertical alignment) type, a CSH (color super-homeotropic) type, and a FLC (ferroelectric liquid crystal). There has been a shift in the driving method used from a conventional static driving to a multiplex driving, which has been commonly employed. Simple-matrix liquid crystal displays and, recently, active-matrix (AM) liquid crystal displays, which are driven using a TFT (thin-film transistor), a TFD (thin-film diode), or the like, have been widely employed.

[0003] As illustrated in Fig. 1, a common liquid crystal display apparatus includes two substrates (1) each including an alignment film (4); a transparent electrode layer (3a) serving as a common electrode and a color filter layer (2), which are interposed between one of the alignment film and the corresponding substrate; and a pixel electrode layer (3b) interposed between the other alignment film and the corresponding substrate. The two substrates are arranged so that the alignment films face each other, and a liquid crystal layer (5) is held therebetween.

[0004] The color filter layer includes a color filter constituted by a black matrix, a red-colored layer (R), a green-colored layer (G), a blue-colored layer (B), and, as needed, a yellow-colored layer (Y).

[0005] The amount of impurities contained in a liquid crystal material constituting the liquid crystal layer is strictly controlled because any impurities remaining in the liquid crystal material would greatly affect the electrical characteristics of the display apparatus. It is known that the material constituting the alignment film also affects the electrical characteristics of the liquid crystal layer because any impurities remaining in the alignment film, which is in direct contact with the liquid crystal layer, would migrate into the liquid crystal layer. Thus, the characteristics of the liquid crystal display apparatus due to impurities contained in a material of the alignment film is currently being studied.

[0006] As well as a material of the alignment film, a material of the color filter layer, such as an organic pigment, is also considered to affect the liquid crystal layer due to impurities contained in the material of the color filter layer. The direct effect of a material of the color filter layer on the liquid crystal layer has been considered to be very small compared with the effect of a material of the alignment film since the alignment film and the transparent electrode are interposed between the color filter layer and the liquid crystal layer. However, the thickness of the alignment film is generally 0.1 μm or less, and the thickness of the transparent electrode serving as a common electrode disposed on the color-filter-layer side is generally 0.5 μm or less, even in the case where the thickness of the transparent electrode is increased in order to increase electrical conductivity. Therefore, it cannot be said that the color filter layer and the liquid crystal layer are in an environment where they are completely isolated from each other. Consequently, the impurities contained in the color filter layer, which migrate via an alignment film and a transparent electrode, may reduce the voltage holding ratio (VHR) of the liquid crystal layer and may increase the ion density (ID) in the liquid crystal layer, which results in faulty display such as white missing pixels, alignment inconsistencies, and burn-in.

[0007] In order to address the faulty display caused by impurities contained in pigments constituting the color filter, a method of controlling elution of impurities into a liquid crystal by using a pigment such that the proportion of a substance extracted from the pigment with ethyl formate is set to be equal to or less than a specific value (PTL 1) and a method of controlling elution of impurities into a liquid crystal by specifying a pigment contained in a blue colored layer (PTL 2) have been studied. However, there is not a great difference between these methods and a method of simply reducing the amount of impurities contained in a pigment, and these methods provide unsatisfactory improvements in addressing the faulty display in the present situation in which progress has been made in purification techniques for pigments.

[0008] On the other hand, focusing on the relationship between organic impurities contained in the color filter and the liquid crystal composition, a method in which the degree of difficulty in dissolving organic impurities in the liquid crystal layer is represented as a hydrophobicity parameter of liquid crystal molecules contained in the liquid crystal layer and the hydrophobicity parameter is controlled to be equal to or more than a specific value; and, on the basis of the correlation between the hydrophobicity parameter and a-OCF_3 group at the end of the liquid crystal molecule, a method in which the content of a liquid crystal compound having an -OCF_3 group at the end of the liquid crystal molecule in a liquid crystal composition is controlled to a specific value or more have been disclosed (PTL 3). However, the essence of the invention disclosed in the cited document is reducing the effect of impurities contained in a pigment on the liquid crystal layer, and there was no study on the direct relationship between the structure of a pigment used for producing a color filter and the

structure of a liquid crystal material.

[0009] It has been disclosed that voltage holding ratio (VHR) may be increased by using a pigment washed with deionized water until the specific electrical conductivity of the filtrate of the deionized water used for the washing treatment reaches 20 μS/cm or less. However, there is no description about the specific electrical conductivity of the pigment, and the voltage holding ratio was about 95% (PTL 4), which was insufficient to address the faulty display of liquid crystal display elements, which are becoming more advanced.

[0010] It is known that the water-soluble content and the specific electrical conductivity of a pigment may affect the anticorrosive effect of an anticorrosive paint and ease of ejecting ink-jet ink (PTL 5 and PTL 6). However, it is not known how the combination of the water-soluble content and specific electrical conductivity of a pigment and the structure of a liquid crystal material constituting a liquid crystal layer affect faulty display of a liquid crystal display element. Thus, the issue of faulty display of liquid crystal display apparatuses, which are becoming more advanced, has not yet been addressed.

Citation List

Patent Literature

[0011]

PTL 1: Japanese Unexamined Patent Application Publication No. 2000-19321
PTL 2: Japanese Unexamined Patent Application Publication No. 2009-109542
PTL 3: Japanese Unexamined Patent Application Publication No. 2000-192040
PTL 4: Japanese Unexamined Patent Application Publication No. 2009-7432
PTL 5: Japanese Unexamined Patent Application Publication No. 2008-144105
PTL 6: Japanese Unexamined Patent Application Publication No. 2010-260997

Summary of Invention

Technical Problem

[0012] The present invention provides a liquid crystal display apparatus including a specific liquid crystal composition and a color filter including a pigment having a certain water-soluble content and/or a certain specific electrical conductivity, which may limit a reduction in the voltage holding ratio (VHR) of a liquid crystal layer and limit an increase in the ion density (ID) in the liquid crystal layer and address issues of faulty display such as white missing pixels, alignment inconsistencies, and burn-in.

Solution to Problem

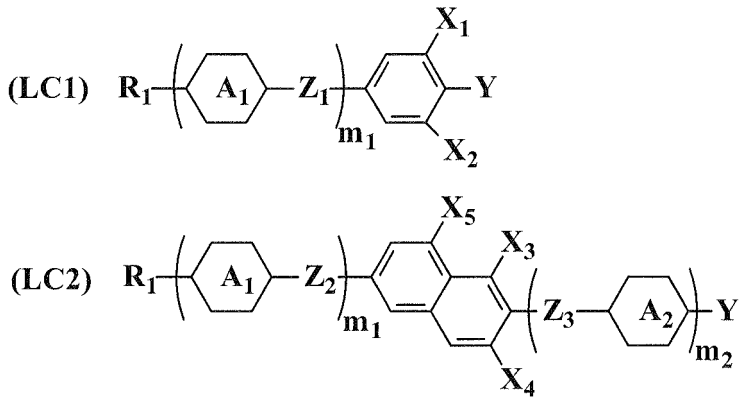
[0013] In order to address the above-described issues, the inventors of the present invention have conducted extensive studies on the combination of the water-soluble content and/or specific electrical conductivity of a pigment constituting a color filter and the structure of a liquid crystal material constituting a liquid crystal layer. As a result, the inventors have found that a liquid crystal display apparatus that includes a liquid crystal material having a specific structure and a color filter prepared using a pigment having a certain water-soluble content and/or a certain specific electrical conductivity may limit a reduction in the voltage holding ratio (VHR) of a liquid crystal layer and limit an increase in the ion density (ID) in the liquid crystal layer and address the issues of faulty display such as white missing pixels, alignment inconsistencies, and burn-in. Thus, the present invention was made.

[0014] Specifically, the present invention provides

a liquid crystal display apparatus including a first substrate, a second substrate, a liquid crystal composition layer held between the first substrate and the second substrate, a color filter including a black matrix and at least RGB three-color pixel portions, a pixel electrode, and a common electrode.

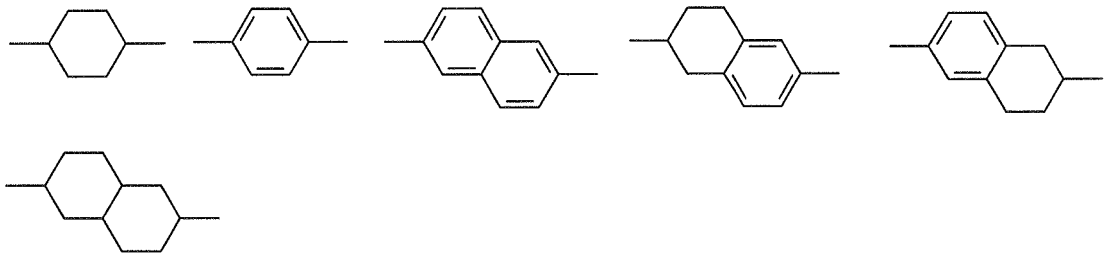
[0015] The liquid crystal composition layer is composed of a liquid crystal composition including one or more compounds selected from a group consisting of compounds represented by General Formula (LC1) and General Formula (LC2). The amount of the one or more compounds is more than 90% by mass of the total amount of liquid crystal compounds having a dielectric anisotropy of 2 or more.

[Chem. 1]



[0016] (where R_1 each independently represents an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, - COO-, -C=C-, $-CF_2O-$ or $-OCF_2-$ in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; one or more hydrogen atoms of the alkyl group may optionally be replaced by a halogen; A_1 and A_2 each independently represent any one of the following structures:

[Chem. 2]



[0017] (in these structures, one or more CH_2 groups of the cyclohexane ring may be replaced by an oxygen atom, one or more CH groups of the benzene ring may be replaced by a nitrogen atom, and one or more hydrogen atoms may be replaced by F, Cl, CF_3, or OCF_3); X_1 to X_5 each independently represent a hydrogen atom, Cl, F, CF_3, or OCF_3; Y each independently represents a hydrogen atom, Cl, F, CF_3, OCH_2F, $OCHF_2$, or OCF_3; Z_1 to Z_3 each independently represent a single bond, -CH=CH-, -CF=CF-, -C=C-, $-CH_2CH_2-$, $-(CH_2)_4-$,$-OCH_2-$, $-CH_2O-$, $-OCF_2-$, $-CF_2O-$, -COO-, or -OCO-; m_1 and m_2 are each independently an integer of 0 to 3; and $m_1 + m_2$ is 1, 2, or 3) .

[0018] The RGB three-color pixel portions include, as a coloring material, a pigment having a water-soluble content of 0% by mass or more and 1.5% by mass or less and/or a specific electrical conductivity of 10 μS/cm or more and 150 μS/cm or less.

Advantageous Effects of Invention

[0019] The liquid crystal display apparatus according to the present invention includes a specific liquid crystal composition and a color filter including a pigment having a certain water-soluble content and/or a certain specific electrical conductivity, which may limit a reduction in the voltage holding ratio (VHR) of a liquid crystal layer and limit an increase in the ion density (ID) in the liquid crystal layer and address issues of faulty display such as white missing pixels, alignment inconsistencies, and burn-in. Brief Description of Drawings

[Fig. 1] Fig. 1 is a diagram illustrating an example of a common liquid crystal display apparatus of the related art.
[Fig. 2] Fig. 2 is a diagram illustrating an example of a liquid crystal display apparatus according to the present invention.

Reference Signs List

[0020]

1	Substrate
2	Color filter layer
2a	Color filter layer including a specific pigment
3a	Transparent electrode layer (common electrode)
3b	Pixel electrode layer
4	Alignment film
5	Liquid crystal layer
5a	Liquid crystal layer including a specific liquid crystal composition

Description of Embodiments

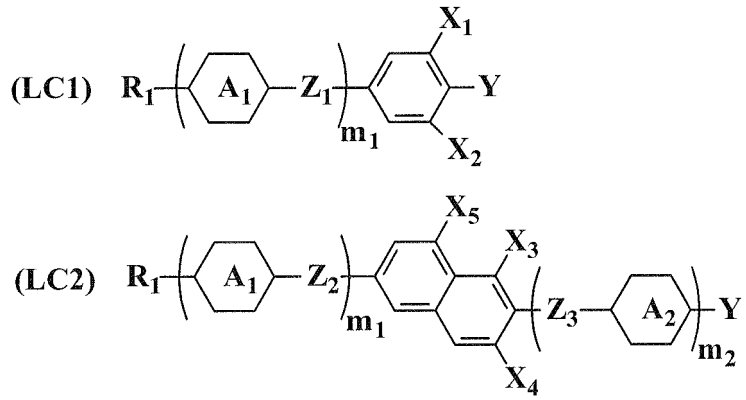
[0021] Fig. 2 illustrates an example of the liquid crystal display apparatus according to the present invention, which includes two substrates (1), namely, a first substrate and a second substrate, each including an alignment film (4); a transparent electrode layer (3a) serving as a common electrode and a color filter layer (2a) including a specific pigment, which are interposed between one of the alignment films and the corresponding substrate; and a pixel electrode layer (3b) interposed between the other alignment film and the corresponding substrate. The two substrates are arranged so that the alignment films face each other, and a liquid crystal layer (5a) including a specific liquid crystal composition is held therebetween.

[0022] The two substrates of the display apparatus are bonded together using a sealant and an encapsulant disposed in the periphery of the substrates. In many cases, granular spacers or resin spacer pillars formed by photolithography are disposed between the substrates in order to maintain a certain distance between the substrates.

(Liquid Crystal Layer)

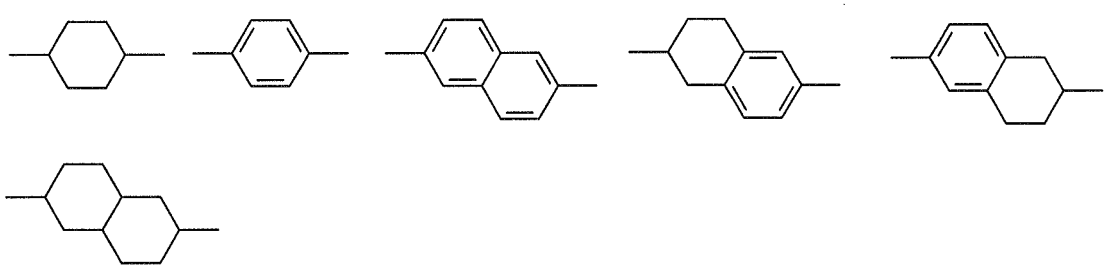
[0023] The liquid crystal layer included in the liquid crystal display apparatus according to the present invention is composed of a liquid crystal composition including one or more compounds selected from a group consisting of compounds represented by General Formula (LC1) and General Formula (LC2). The amount of the compounds is more than 90% by mass of the total amount of liquid crystal compounds having a dielectric anisotropy of 2 or more.

[Chem. 3]



[0024] (where R_1 each independently represents an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, - COO-, -C=C-, $-CF_2O-$, or $-OCF_2-$ in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; one or more hydrogen atoms of the alkyl group may optionally be replaced by a halogen; A_1 and A_2 each independently represent any one of the following structures:

[Chem. 4]

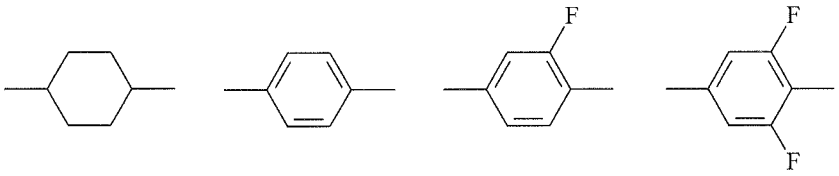


[0025] (in these structures, one or more CH_2 groups of the cyclohexane ring may be replaced by an oxygen atom, one or more CH groups of the benzene ring may be replaced by a nitrogen atom, and one or more hydrogen atoms may be replaced by F, Cl, CF_3, or OCF_3); X_1 to X_5 each independently represent a hydrogen atom, Cl, F, CF_3, or OCF_3; Y each independently represents a hydrogen atom, Cl, F, CF_3, OCH_2F, $OCHF_2$, or OCF_3; Z_1 to Z_3 each independently represent a single bond, -CH=CH-, -CF=CF-, -C≡C-, $-CH_2CH_2-$, - $-(CH_2)_4-$,$-OCH_2-$, $-CH_2O-$, $-OCF_2-$, $-CF_2O-$, -COO-, or -OCO-; m_1 and m_2 are each independently an integer of 0 to 3; and $m_1 + m_2$ is 1, 2, or 3) .

[0026] R_1 is preferably each independently an alkyl group having 1 to 7 carbon atoms, an alkoxy group having 1 to 7 carbon atoms, or an alkenyl group having 2 to 7 carbon atoms and is more preferably each independently an alkyl group having 1 to 5 carbon atoms, an alkoxy group having 1 to 5 carbon atoms, or an alkenyl group having 2 to 5 carbon atoms.

[0027] A_1 and A_2 are preferably each independently any one of the following structures:

[Chem. 5]



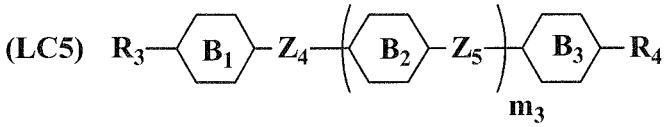
[0028] Y is preferably each independently F, CF_3, or OCF_3 and is particularly preferably F.

[0029] Z_1 to Z_3 are preferably each independently a single bond, $-CH_2CH_2-$, -COO-, -OCO-, $-OCH_2-$, $-CH_2O-$, $-OCF_2-$, or $-CF_2O-$ and are more preferably each independently a single bond,$-CH_2CH_2-$, $-OCF_2-$, or $-CF_2O-$, and

[0030] m_1 and m_2 are preferably each independently 1 or 2.

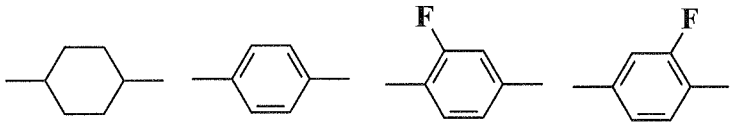
[0031] The above-described liquid crystal composition preferably further includes one or more compounds represented by General Formula (LC5) below:

[Chem. 6]



[0032] (in General Formula (LC5), R_3 and R_4 each independently represent an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, - CH=CH-, -CO-, -OCO-, -COO-, -C=C-, $-CF_2O-$, or $-OCF_2-$ in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; one or more hydrogen atoms of the alkyl group may optionally be replaced by a halogen; B_1 to B_3 each independently represent any one of the following structures:

[Chem. 7]

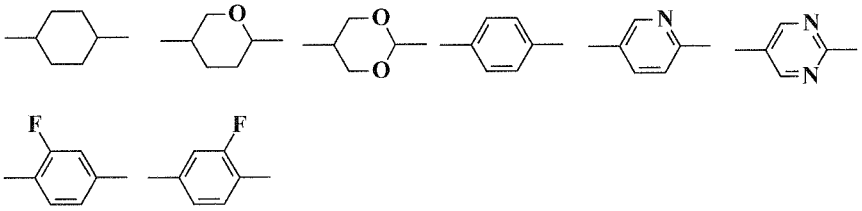


[0033] (in these structures, one or more CH_2CH_2 groups of the cyclohexane ring may be replaced by -CH=CH-, $-CF_2O-$, or-OCF_2- and one or more CH groups of the benzene ring may be replaced by a nitrogen atom); Z_4 and Z_5 each independently represent a single bond, -CH=CH-, -CF=CF-, -C=C-, $-CH_2CH_2-$,$-(CH_2)_4-$, -COO-, $-OCH_2-$, $-CH_2O-$, $-OCF_2-$, or $-CF_2O-$; and m_3 is 0 to 3) .

[0034] R_3 and R_4 are preferably each independently an alkyl group having 1 to 7 carbon atoms, an alkoxy group having 1 to 7 carbon atoms, an alkenyl group having 2 to 7 carbon atoms, or an alkenyloxy group having 2 to 7 carbon atoms and are more preferably each independently an alkyl group having 1 to 5 carbon atoms, an alkoxy group having 1 to 5 carbon atoms, or an alkenyl group having 2 to 5 carbon atoms.

[0035] B_1 to B_3 are preferably each independently any one of the following structures:

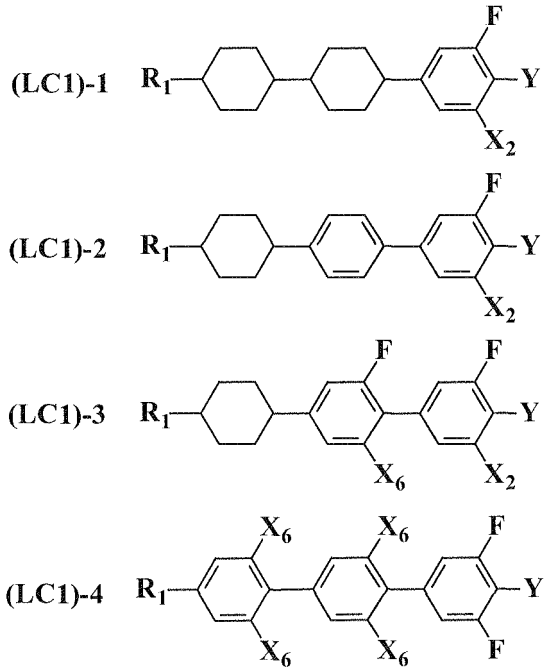
[Chem. 8]



Z_4 and Z_5 are preferably each independently a single bond, $-CH_2CH_2-$, -COO-, $-OCH_2-$, $-CH_2O-$, $-OCF_2-$, or $-CF_2O-$ and are more preferably each independently a single bond or-CH_2CH_2-, and
m_3 is preferably 0, 1, or 2.

[0036] The compound represented by General Formula (LC1) is preferably one or more compounds selected from the group consisting of the compounds represented by General Formula (LC1)-1 to General Formula (LC1)-4 below:

[Chem. 9]



[0037] (in General Formulae (LC1)-1 to (LC1)-4, R_1 each independently represents an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, -COO-, -C=C-, - CF_2O-, or -OCF_2- in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; X_2 and X_6 each independently represent a hydrogen atom, Cl, F, CF_3, or OCF_3; when a plurality of X_6's are present, they may be identical or different; and Y each independently represents Cl, F, CF_3, OCH_2F, $OCHF_2$, or OCF_3).

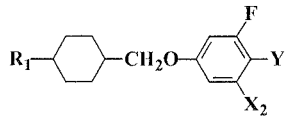
[0038] R_1 is preferably each independently an alkyl group having 1 to 7 carbon atoms, an alkoxy group having 1 to 7 carbon atoms, or an alkenyl group having 2 to 7 carbon atoms and is more preferably an alkyl group having 1 to 5 carbon atoms, an alkoxy group having 1 to 5 carbon atoms, or an alkenyl group having 2 to 5 carbon atoms.

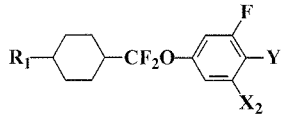
[0039] X_2 and X_6 are preferably each independently a hydrogen atom or F.

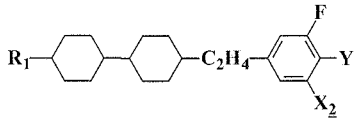
[0040] Y is preferably each independently F, CF_3, or OCF_3.

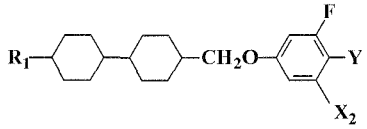
[0041] The compound represented by General Formula (LC1) is preferably one or more compounds selected from the group consisting of the compounds represented by General Formula (LC1)-5 to General Formula (LC1)-24 below:

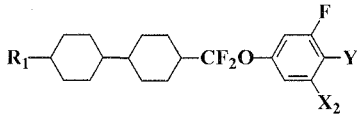
[Chem. 10]

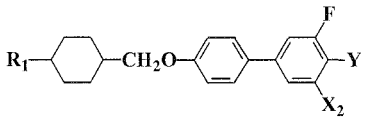
(LC1)-5 

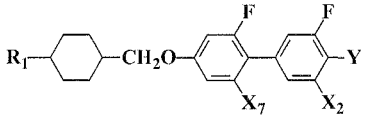
(LC1)-6 

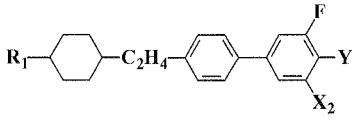
(LC1)-7 

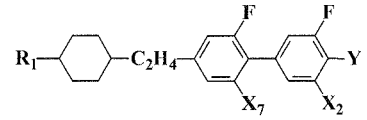
(LC1)-8 

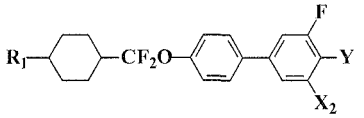
(LC1)-9 

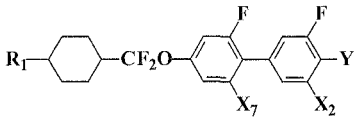
(LC1)-10 

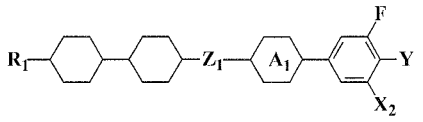
(LC1)-11 

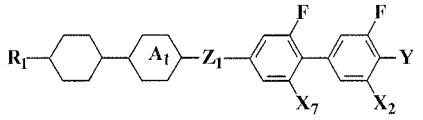
(LC1)-12 

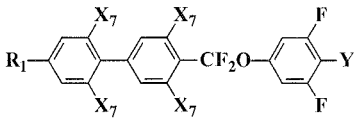
(LC1)-13 

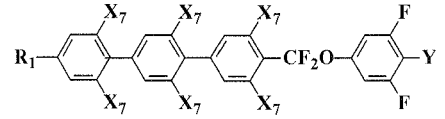
(LC1)-14 

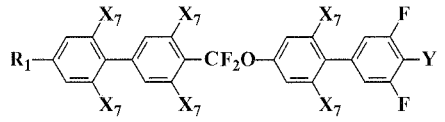
(LC1)-15 

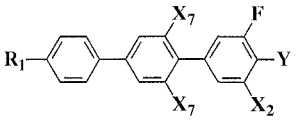
(LC1)-16 

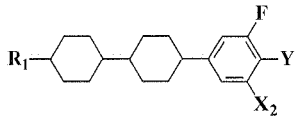
(LC1)-17 

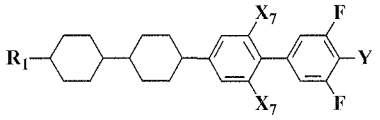
(LC1)-18 

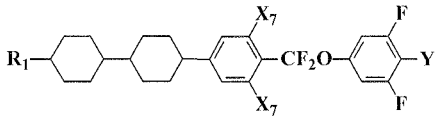
(LC1)-19 

(LC1)-20 

(LC1)-21 

(LC1)-22 

(LC1)-23 

(LC1)-24 

[0042] (in General Formulae (LC1)-5 to (LC1)-24, R_1 each independently represents an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, -COO-, -C≡C-, - CF_2O-, or -OCF_2- in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; one or more hydrogen atoms of the alkyl group may optionally be replaced by a halogen; X_2 and X_7 each independently represent a hydrogen atom, Cl, F, CF_3, or OCF_3; when a plurality of X_7's are present, they may be identical or different; Z_1 each independently represents a single bond, -CH=CH-, -C≡C-,-CH_2CH_2-, -$(CH_2)_4$-, -OCH_2-, -CH_2O-, -OCF_2-, or -CF_2O-; Y each independently represents Cl, F, CF_3, OCH_2F, $OCHF_2$, or OCF_3; and

[Chem. 11]

[0043] A^1 each independently represents any one of the above structures).

[0044] R_1 is preferably each independently an alkyl group having 1 to 7 carbon atoms, an alkoxy group having 1 to 7 carbon atoms, or an alkenyl group having 2 to 7 carbon atoms and is more preferably an alkyl group having 1 to 5 carbon atoms, an alkoxy group having 1 to 5 carbon atoms, or an alkenyl group having 2 to 5 carbon atoms.

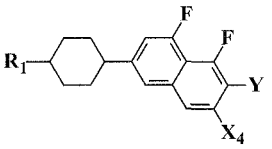
[0045] X_2 and X_7 are preferably each independently a hydrogen atom or F.

[0046] Y is preferably each independently F, CF_3, or OCF_3.

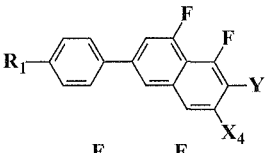
[0047] The compound represented by General Formula (LC2) is preferably one or more compounds selected from the group consisting of the compounds represented by General Formula (LC2)-1 to General Formula (LC2)-11 below:

[Chem. 12]

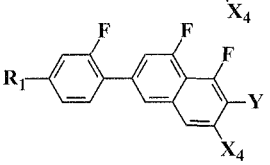
(LC2)-1



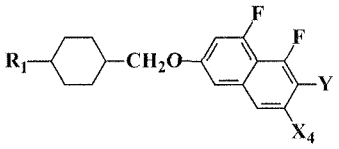
(LC2)-2



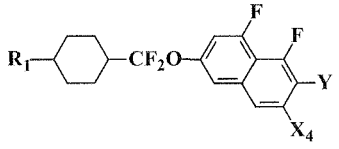
(LC2)-3



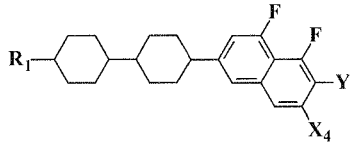
(LC2)-4



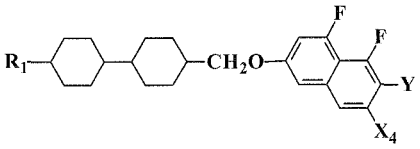
(LC2)-5



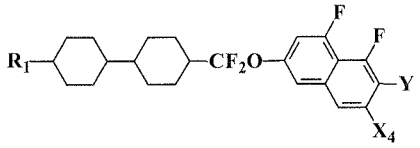
(LC2)-6



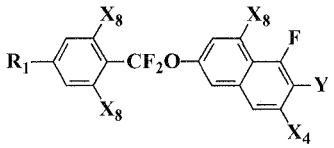
(LC2)-7



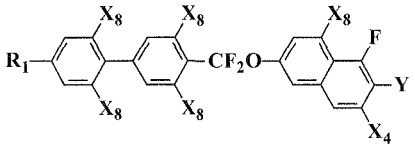
(LC2)-8



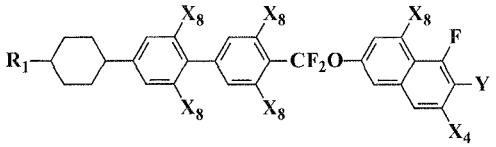
(LC2)-9



(LC2)-10



(LC2)-11



[0048] (in General Formulae (LC2)-1 to (LC2)-11, R_1 each independently represents an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, -COO-, -C≡C-, - CF_2O-, or -OCF_2- in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; X_4 and X_8 each independently represent a hydrogen atom, Cl, F, CF_3, or OCF_3; when a plurality of X_8's are present, they may be identical or different; Y each independently represents Cl, F, CF_3, OCH_2F, $OCHF_2$, or OCF_3).

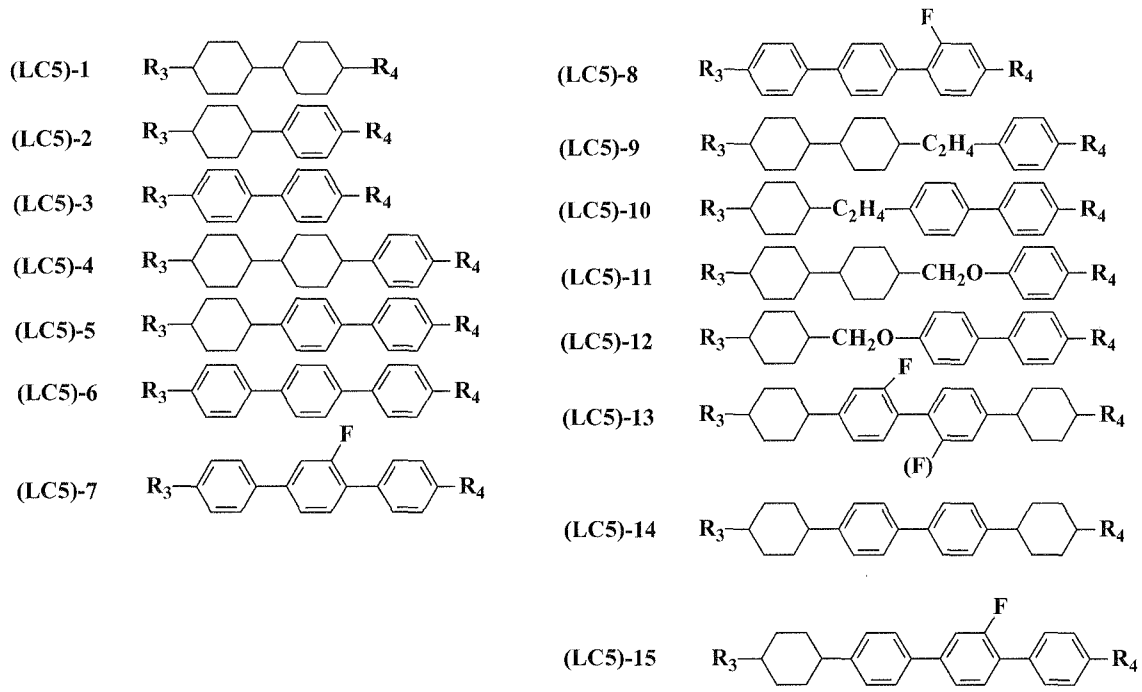
[0049] R_1 is preferably each independently an alkyl group having 1 to 7 carbon atoms, an alkoxy group having 1 to 7 carbon atoms, or an alkenyl group having 2 to 7 carbon atoms and is more preferably an alkyl group having 1 to 5 carbon atoms, an alkoxy group having 1 to 5 carbon atoms, or an alkenyl group having 2 to 5 carbon atoms.

[0050] X_4 and X_8 are preferably each independently a hydrogen atom or F.

[0051] Y is preferably each independently F, CF_3, or OCF_3.

[0052] The compound represented by General Formula (LC5) is more preferably one or more compounds selected from the group consisting of the compounds represented by General Formula (LC5)-1 to General Formula (LC5)-15 below:

[Chem. 13]

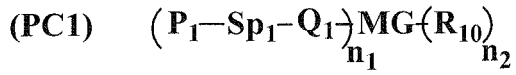


[0053] (in General Formulae (LC5)-1 to (LC5)-15, R_3 and R_4 each independently represent an alkyl group having 1 to 7 carbon atoms, an alkoxy group having 1 to 7 carbon atoms, an alkenyl group having 2 to 7 carbon atoms, or an alkenyloxy group having 2 to 7 carbon atoms). R_3 and R_4 are more preferably each independently an alkyl group having 1 to 5 carbon atoms, an alkoxy group having 1 to 5 carbon atoms, or an alkenyl group having 2 to 5 carbon atoms.

[0054] The above-described liquid crystal composition layer may include one or more polymerizable compounds.

[0055] Specifically, the above-described liquid crystal composition layer preferably includes one or more polymerizable compounds represented by General Formula (PC1) below:

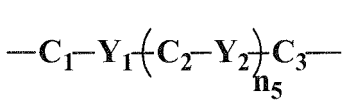
[Chem. 14]



[0056] (in General Formula (P1), P_1 represents a polymerizable functional group; Sp_1 represents a spacer group having 0 to 20 carbon atoms; Q_1 represents a single bond, -O-, -NH-, - NHCOO-, -OCONH-, -CH=CH-, -CO-, -COO-, -OCO-, -OCOO-, -OOCO-, -CH=CH-, -CH=CH-COO-, -OCO-CH=CH-, or -C≡C-; n_1 and n_2 represent 1, 2, or 3; MG represents a mesogenic group or a mesogenic supporting group; R_{10} represents a halogen atom, a cyano group, or an alkyl group having 1 to 25 carbon atoms, and one or more CH_2 groups of the alkyl group may be replaced by -O-, -S-, -NH-, -N(CH_3)-, -CO-, -COO-, -OCO-,-OCOO-, -SCO-, -COS-, or -C=C- in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; and, in another case, R_{10} represents P_2-Sp_2-Q_2- (where P_2, Sp_2, Q_2 independently represent the same things as P_1, Sp_1, Q_1, respectively)).

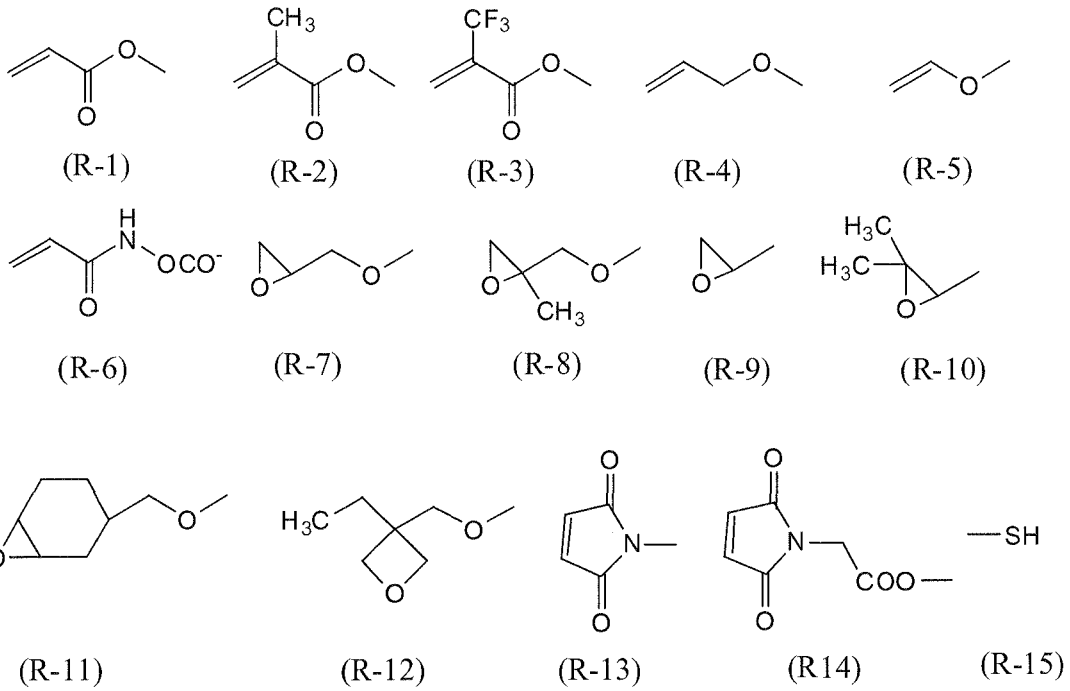
[0057] In General Formula (PC1), more preferably, MG represents the following structure:

[Chem. 15]



[0058] (where C_1 to C_3 each independently represent a 1,4-phenylene group, a 1,4-cyclohexylene group, a 1,4-cyclohexenyl group, a tetrahydropyran-2,5-diyl group, a 1,3-dioxane-2,5-diyl group, a tetrahydrothiopyran-2,5-diyl group, a 1,4-bicyclo(2,2,2)octylene group, a decahydronaphthalene-2,6-diyl group, a pyridine-2,5-diyl group, a pyrimidine-2,5-diyl group, a pyrazine-2,5-diyl group, a 1,2,3,4-tetrahydronaphthalene-2,6-diyl group, a 2,6-naphthylene group, a phenanthrene-2,7-diyl group, a 9,10-dihydrophenanthrene-2,7-diyl group, a 1,2,3,4,4a,9,10a-octahydrophenanthrene 2,7-diyl group, or a fluorene 2,7-diyl group; the 1,4-phenylene group, the 1,2,3,4-tetrahydronaphthalene-2,6-diyl group, the 2,6-naphthylene group, the phenanthrene-2,7-diyl group, the 9,10-dihydrophenanthrene-2,7-diyl group, the 1,2,3,4,4a,9,10a-octahydrophenanthrene 2,7-diyl group, and the fluorene 2,7-diyl group may include, as a substituent, one or more F atoms, Cl atoms, CF_3 groups, OCF_3 groups, cyano groups, alkyl groups having 1 to 8 carbon atoms, alkoxy groups having 1 to 8 carbon atoms, alkanoyl groups having 1 to 8 carbon atoms, alkanoyloxy groups having 1 to 8 carbon atoms, alkenyl groups having 2 to 8 carbon atoms, alkenyloxy groups having 2 to 8 carbon atoms, alkenoyl groups having 2 to 8 carbon atoms, or alkenoyloxy groups having 2 to 8 carbon atoms; Y_1 and Y_2 each independently represent -COO-, -OCO-, $-CH_2CH_2-$,$-OCH_2-$, $-CH_2O-$, -CH=CH-, -C=C-, -CH=CHCOO-, -OCOCH=CH-,$-CH_2CH_2COO-$, $-CH_2CH_2OCO-$, $-COOCH_2CH_2-$, $-OCOCH_2CH_2-$, -CONH-, - NHCO-, or a single bond; and n_5 is 0, 1, or 2). Sp_1 and Sp_2 are more preferably each independently an alkylene group, which may be substituted by one or more halogen atoms or cyano groups. One or more CH_2 groups of the alkylene group may be replaced by -O-, -S-, -NH-, $-N(CH_3)-$, -CO-, -COO-, - OCO-, -OCOO-, -SCO-, -COS-, or -C≡C- in such a manner that an oxygen atom is not directly adjacent to another oxygen atom. P_1 and P_2 are preferably each independently any one of the structures represented by Formula (R-1) to Formula (R-15) below:

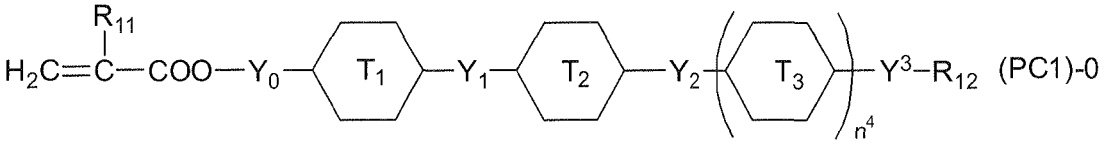
[Chem. 16]



[0059] Such polymerizable groups can be cured by radical polymerization, radical addition polymerization, cationic polymerization, or anionic polymerization. In the case where polymerization is performed by ultraviolet light polymerization, the structures represented by Formulae (R-1), (R-2), (R-4), (R-5), (R-7), (R-11), (R-13), and (R-15) are preferably employed. The structures represented by Formulae (R-1), (R-2), (R-7), (R-11), and (R-13) are more preferably employed. The structures represented by Formulae (R-1) and (R-2) are more preferably employed.

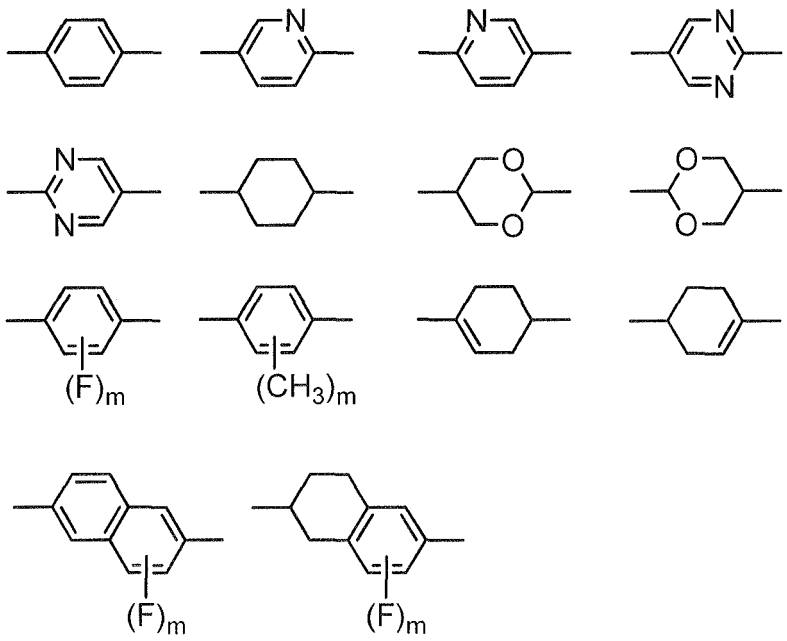
[0060] An example of a polymerizable compound including one polymerizable functional group in the molecule is the compound represented by General Formula (PC1)-0 below:

[Chem. 17]



[0061] (in Formula (PC1)-0, R_{11} represents a hydrogen atom or a methyl group; the six-membered rings T_1, T_2, and T_3 each independently represent any one of the following structures:

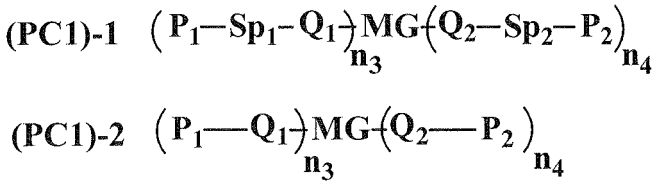
[Chem. 18]



(where m represents an integer of 1 to 4);
n_4 represents an integer of 0 or 1;
Y_0, Y_1, and Y_2 each independently represent a single bond, -O-, $-OCH_2-$, $-OCH_2-$, $-C_2H_4-$, -COO-, -OCO-, -CH=CH-,-CO-, -OCOO-, -NH-, -NHCOO-, -OCONH-, $-OCOCH_2-$, $-CH_2OCO-$,$-COOCH_2-$, $-CH_2COO-$, -CH=CH-COO-, -OCO-CH=CH-, -CH=CH-OCO-,-COO-CH=CH-, $-CH=CCH_3-COO-$, $-COO-CCH_3=CH-$, $-COOC_2H_4-$, $-OCOC_2H_4-$, $-C_2H_4OCO-$, $-C_2H_4COO-$, -C=C-, $-CF_2O-$, or $-OCF_2-$;
Y_3 represents a single bond, -O-, -COO-, or -OCO-; and
R_{12} represents a hydrogen atom, a halogen atom, a cyano group, an alkyl group having 1 to 20 carbon atoms, an alkenyl group having 1 to 20 carbon atoms, an alkoxy group having 1 to 20 carbon atoms, or a hydrocarbon group having 1 to 20 carbon atoms). At least one polymerizable compound selected from the group is preferably used.

[0062] Examples of a polymerizable compound including two or more polymerizable functional groups in the molecule include the compounds represented by General Formula (PC1)-1 and General Formula (PC1)-2 below:

[Chem. 19]



(PC1)-1

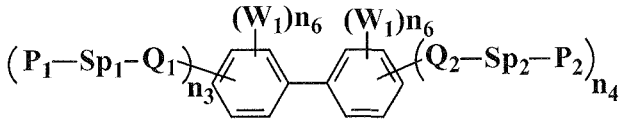
(PC1)-2

[0063] (where P_1, Sp_1, Q_1, P_2, Sp_2, Q_2, and MG represent the same things as in General Formula (PC1), and n_3 and n_4 are each independently 1, 2, or 3).

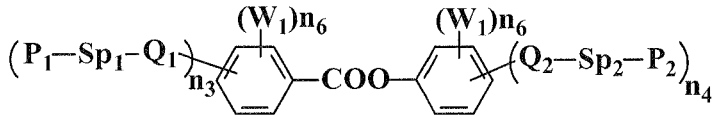
[0064] Specifically, the compound represented by General Formula (PC1) is preferably one or more polymerizable compounds selected from the group consisting of the compounds represented by General Formula (PC1)-3 to General Formula (PC1)-11 below:

[Chem. 20]

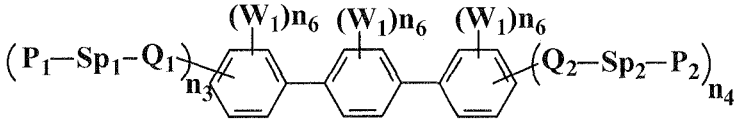
(PC1)-3



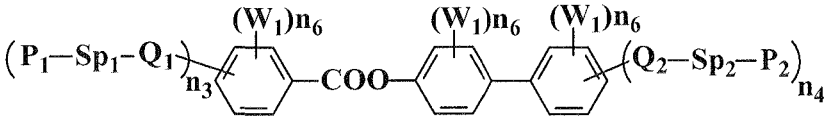
(PC1)-4



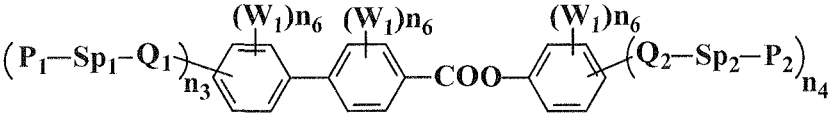
(PC1)-5



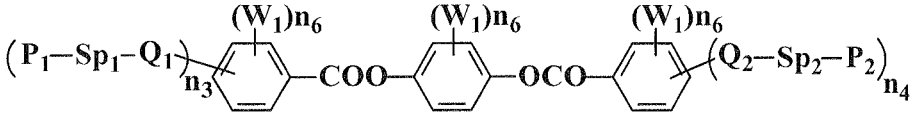
(PC1)-6



(PC1)-7

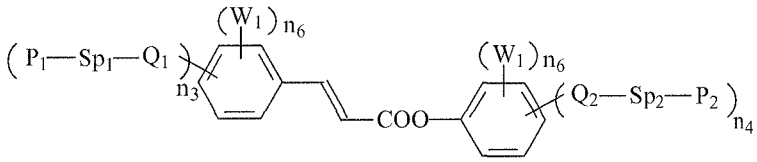


(PC1)-8

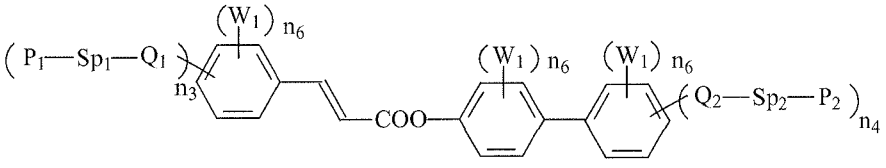


[Chem. 21]

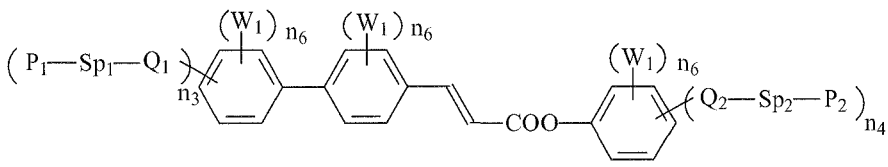
(PC1)-9



(PC1)-10



(PC1)-11



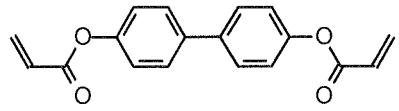
[0065] (in General Formula (PC1)-3 to General Formula (PC1)-11, P_1, P_2, Sp_1, Sp_2, Q_1, and Q_2 represent the same things as in General Formula (PC1); W_1's each independently represent F, CF_3, OCF_3, CH_3, OCH_3, an alkyl group having 2 to 5 carbon atoms, an alkoxy group having 2 to 5 carbon atoms, an alkenyl group having 2 to 5 carbon atoms, $COOW_2$, $OCOW_2$, or $OCOOW_2$ (where W_2 each independently represents a straight-chain or branched chain alkyl group having 1 to 10 carbon atoms or an alkenyl group having 2 to 5 carbon atoms); n_3 each independently represents 1, 2, or 3; n_4 each independently represents 1, 2, or 3; n_6's each independently represent 0, 1, 2, 3, or 4; and, in the same ring, $n_3 + n_6$ and $n_4 + n_6$ are 5 or less).

[0066] In General Formula (PC1) and General Formula (PC1)-1 to General Formula (PC1)-11, Sp_1, Sp_2, Q_1, and Q_2 are preferably a single bond. The value of $n_3 + n_4$ is preferably 1 to 3 and is preferably 1 or 2. P_1 and P_2 are preferably the polymerizable group represented by Formula (R-1) or (R-2). W_1 is preferably F, CF_3, OCF_3, CH_3, or OCH_3. The value of n_6 is 1, 2, 3, or 4.

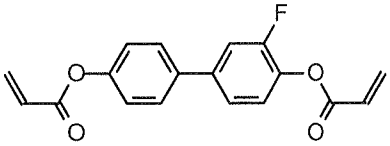
[0067] Specifically, the polymerizable compound represented by General Formula (PC1) is preferably one or more polymerizable compounds selected from the group consisting of the following compounds:

[Chem. 22]

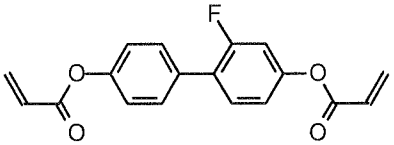
(PC1-3a)



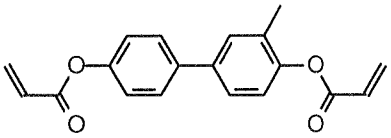
(PC1-3b)



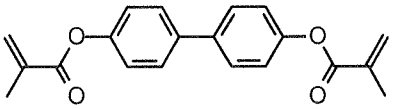
(PC1-3c)



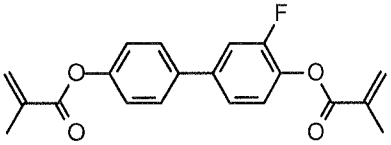
(PC1-3d)



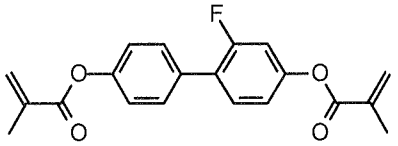
(PC1-3e)



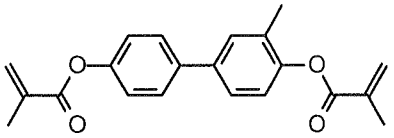
(PC1-3f)



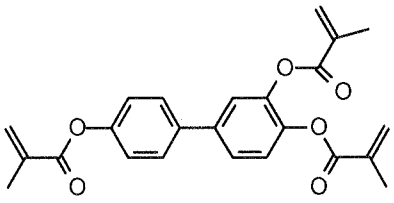
(PC1-3g)



(PC1-3h)



(PC1-3i)

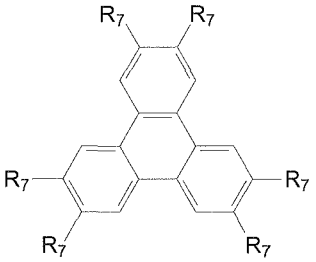


[0068] Optionally, a hydrogen atom of the benzene rings of (PC1-3a) to (PC1-3i) may be replaced by a fluorine atom.

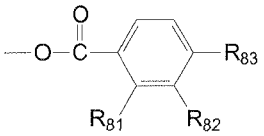
[0069] It is also preferable that the polymerizable compound is the disc-shaped liquid crystal compound represented by General Formula (PC1)-12 below:

[Chem. 23]

(PC1)-12



(PC1-e)



[0070] (in General Formula (PC1)-12, R_7's each independently represent P_1-Sp_1-Q_1 or a substituent represented by General Formula (PC1-e), where P_1, Sp_1, and Q_1 represent the same things as in General Formula (PC1), R_8, and R_{82} each independently represent a hydrogen atom, a halogen atom, or a methyl group, R_{83} represents an alkoxy group having 1 to 20 carbon atoms, and at least one hydrogen atom of the alkoxy group is replaced by any one of the substituents represented by Formulae (R-1) to (R-15)).

[0071] The amount of the polymerizable compound used is preferably 0.05% to 2.0% by mass.

[0072] The above-described liquid crystal composition may be used alone for the above-described purpose. Optionally, the above-described liquid crystal composition may include one or more types of antioxidants or may further include one or more types of UV absorbents.

(Color Filter)

[0073] The color filter used in the present invention includes a black matrix and at least RGB three-color pixel portions. The RGB three-color pixel portions includes, as a coloring material, a pigment having a water-soluble content of 0.001% by mass or more and 1.5% by mass or less and/or a specific electrical conductivity of 10 μS/cm or more and 150 μS/cm or less.

[0074] The water-soluble content of the pigment is preferably 0% by mass or more and 1.2% by mass or less, is more preferably 0% by mass or more and 1.0% by mass or less, and is particularly preferably 0% by mass or more and 0.8% by mass or less.

[0075] The specific electrical conductivity of the pigment is preferably 10 μS/cm or more and 120 μS/cm or less, is more preferably 10 μS/cm or more and 100 μS/cm or less, and is particularly preferably 10 μS/cm or more and 80 μS/cm or less.

[0076] More specifically, it is preferable that the water-soluble content of the pigment is 0% by mass or more and 1.2% by mass or less and the specific electrical conductivity of the pigment is 10 μS/cm or more and 120 μS/cm or less.

[0077] It is more preferable that the water-soluble content of the pigment is 0% by mass or more and 1.0% by mass or less and the specific electrical conductivity of the pigment is 10 μS/cm or more and 100 μS/cm or less.

[0078] It is particularly preferable that the water-soluble content of the pigment is 0% by mass or more and 0.8% by mass or less and the specific electrical conductivity of the pigment is 10 μS/cm or more and 80 μS/cm or less.

[0079] The term "water-soluble content of the pigment" used herein refers to the content of a constituent of the pigment which dissolves in water. Specifically, the water-soluble content of a pigment can be calculated in accordance with JIS K5101-16-1 (Test methods for pigments-Part 16: Matter soluble in water-Section 1: Hot extraction method), that is, in the following manner:

1. Into a 500-mL rigid beaker, 5.00 g of an accurately weighed pigment is charged. To the beaker, 200 mL of ion-exchange water (electrical conductivity: 5 μS/cm or less, pH: 7.0 ± 1.0) is added. The ion-exchange water is added in small amounts at a time. After 5 mL of first-grade reagent methanol is added to the beaker to soak the pigment in the ion-exchange water to a sufficient degree, the remaining ion-exchange water is added to the beaker. The resulting liquid mixture is boiled for 5 minutes.
2. The liquid mixture is cooled to room temperature, and transferred to a 250-mL graduated cylinder. To the graduated cylinder, the above-described ion-exchange water is added until the volume of the liquid mixture becomes 250 mL. The liquid mixture is vigorously stirred and then filtered through a filter paper No. 5C produced by ADVANTEC.
3. Initially, about 50 mL of the filtrate is removed, and 100 mL of the remaining filtrate is weighed using a graduated cylinder and transferred to an evaporation pan of known mass. The filtrate adhering to the graduated cylinder is washed off with a small amount of ion-exchange water into the evaporation pan.
4. The evaporation pan is placed in a water bath, and evaporation to dryness is performed. The evaporation pan is dried for 2 hours in a drying machine kept at 105°C to 110°C and subsequently charged into a desiccator. After the evaporation pan is left to cool, the mass of the evaporation pan is measured. Thus, the amount of substance that remained after evaporation is determined.

5. The water-soluble content of the pigment is calculated using the following formula.

Water-soluble content of the pigment (%) = Amount of substance remaining after evaporation (g) × 2.5 / Mass of the pigment (g) × 100

[0080] The term "specific electrical conductivity of the pigment" used herein refers to a difference between the specific electrical conductivity of a filtrate obtained by filtering an aqueous solution prepared by hot extraction of the pigment using ion-exchange water and the specific electrical conductivity of the ion-exchange water used, that is, specifically, a difference between the specific electrical conductivity of a filtrate obtained in accordance with JIS K5101-16-1 (Test methods for pigments-Part 16: Matter soluble in water-Section 1: Hot extraction method) and the specific electrical conductivity of the ion-exchange water used.

[0081] Specific electrical conductivity of the pigment = Specific electrical conductivity of the filtrate - Specific electrical conductivity of the ion-exchange water used

[0082] The above-described RGB three-color pixel portions preferably include an R pixel portion including, as a coloring material, a diketopyrrolopyrrole-based red pigment; a G pixel portion including, as a coloring material, a halogenated metal phthalocyanine pigment; and a B pixel portion including, as a coloring material, an ε-type phthalocynian pigment and/or a triarylmethane pigment.

[0083] The diketopyrrolopyrrole pigment included in the R pixel portion is preferably one or more pigments selected from C.I. Pigment Red 254, C.I. Pigment Red 255, C.I. Pigment Red 264, and C.I. Pigment Red 272, C.I. Pigment Orange 71, and C.I. Pigment Orange 73, is more preferably one or more pigments selected from C.I. Pigment Red 254, C.I. Pigment Red 255, C.I. Pigment Red 264, and C.I. Pigment Red 272, and is particularly preferably C.I. Pigment Red 254.

[0084] The halogenated metal phthalocyanine pigment included in the G pixel portion preferably includes a metal selected from the group consisting of Al, Si, Sc, Ti, V, Mg, Fe, Co, Ni, Zn, Cu, Ga, Ge, Y, Zr, Nb, In, Sn, and Pb as a central metal. When the central metal of the halogenated metal phthalocyanine pigment is trivalent, one group selected from a halogen atom, a hydroxyl group, and a sulfonic group is preferably bonded to the central metal or the central metal is preferably oxo-cross-linked or thio-cross-linked. When the central metal of the halogenated metal phthalocyanine pigment is a tetravalent metal, one oxygen atom or two identical or different groups selected from a halogen atom, a hydroxyl group, and a sulfonic group are preferably bonded to the central metal. Examples of such a halogenated metal phthalocyanine pigment include halogenated metal phthalocyanine pigments belonging to the following two groups.

(Group 1)

[0085] Halogenated metal phthalocyanine pigments including a metal selected from the group consisting of Al, Si, Sc, Ti, V, Mg, Fe, Co, Ni, Zn, Cu, Ga, Ge, Y, Zr, Nb, In, Sn, and Pb as a central metal, wherein 8 to 16 halogen atoms per phthalocyanine molecule are bonded to the benzene rings of the phthalocyanine molecule and, when the central metal is trivalent, one group selected from a halogen atom, a hydroxyl group, and a sulfonic group ($-SO_3H$) is bonded to the central metal or, when the central metal is a tetravalent metal, one oxygen atom or two identical or different groups selected from a halogen atom, a hydroxyl group, and a sulfonic group are bonded to the central metal.

(Group 2)

[0086] Pigments that are halogenated metal phthalocyanine dimers having a structural unit constituted by two halogenated metal phthalocyanine molecules each including a trivalent metal selected from the group consisting of Al, Sc, Ga, Y, and In as a central metal and 8 to 16 halogen atoms bonded to the benzene rings of the phthalocyanine molecule, the central metals in the structural unit being bonded to each other via a divalent atomic group selected from the group consisting of an oxygen atom, a sulfur atom, a sulfinyl (-SO-), and a sulfonyl ($-SO_2-$).

[0087] In the halogenated metal phthalocyanine pigment, the halogen atoms bonded to the benzene rings may be all identical or different. Different halogen atoms may be bonded to one benzene ring.

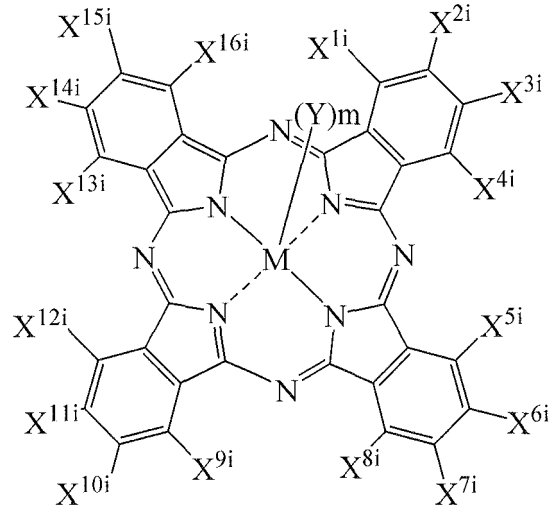
[0088] When 9 to 15 bromine atoms of 8 to 16 halogen atoms per phthalocyanine molecule are bonded to the benzene rings of the phthalocyanine molecule, such a halogenated metal phthalocyanine pigment appears yellowish-light green and is most suitably used for green pixel portions of the color filter. The halogenated metal phthalocyanine pigment is insoluble or hardly soluble in water and organic solvents. The halogenated metal phthalocyanine pigment may be a halogenated metal phthalocyanine pigment that has not yet been subjected to the finishing treatment described below (referred to also as "crude pigment") or may be a halogenated metal phthalocyanine pigment that has been subjected

to the finishing treatment.

[0089] The halogenated metal phthalocyanine pigments belonging to Group 1 or 2 above can be represented by General Formula (PIG-1) below:

[Chem. 24]

(PIG-1)



[0090] In General Formula (PIG-1), the halogenated metal phthalocyanine pigments belonging to Group 1 are as follows.

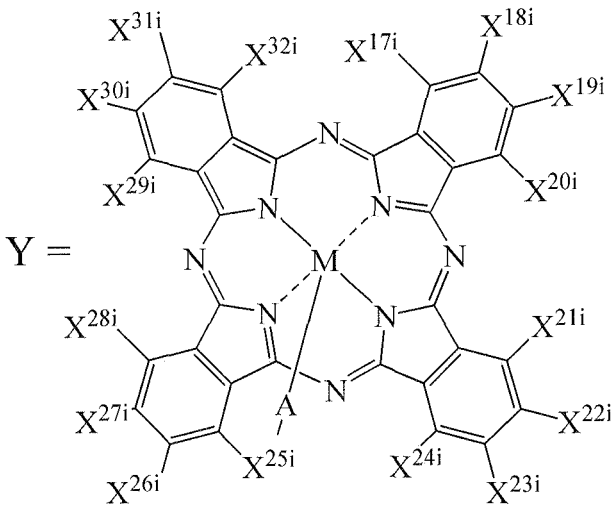
[0091] In General Formula (PIG-1), X^{1i} to X^{16i} represent a hydrogen atom, a chlorine atom, a bromine atom, or an iodine atom. The four X atoms bonded to one benzene ring may be identical or different. Among X^{1i} to X^{16i} bonded to the four benzene rings, 8 to 16 X's are chlorine atoms, bromine atoms, or iodine atoms. M represents a central metal. Among halogenated metal phthalocyanine pigments having the same Y, which is described below, and the same m, which is the number of Y's, a pigment in which, among 16 X's of X^{1i} to X^{16i}, the total number of chlorine atoms, bromine atoms, and iodine atoms is less than 8 appears blue. In the same manner, among pigments in which, among 16 X's of X^{1i} to X^{16i}, the total number of chlorine atoms, bromine atoms, and iodine atoms is 8 or more, the greater the total number of chlorine atoms, bromine atoms, and iodine atoms, the higher the degree of yellow. Y bonded to the central metal M is a monovalent atomic group selected from the group consisting of a halogen atom that is any one of a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; an oxygen atom; a hydroxyl group; and a sulfonic group, and m represents the number of Y's bonded to the central metal M and is an integer of 0 to 2.

[0092] The value of m is determined on the basis of the valence of the central metal M. When the central metal M is trivalent as is the case for Al, Sc, Ga, Y, and In, m = 1. In this case, one group selected from the group consisting of a fluorine atom, a chlorine atom, a bromine atom, an iodine atom, a hydroxyl group, and a sulfonic group is bonded to the central metal. When the central metal M is tetravalent as is the case for Si, Ti, V, Ge, Zr, and Sn, m = 2. In this case, one oxygen atom is bonded to the central metal, or two groups selected from the group consisting of a fluorine atom, a chlorine atom, a bromine atom, an iodine atom, a hydroxyl group, and a sulfonic group are bonded to the central metal. When the central metal M is divalent as is the case for Mg, Fe, Co, Ni, Zn, Cu, Zr, Sn, and Pb, Y is absent.

[0093] In General Formula (PIG-1) shown above, the halogenated metal phthalocyanine pigments belonging to Group 2 are as follows.

[0094] In the General Formula (PIG-1), X^{1i} to X^{16i} are the same as defined above, the central metal M represents a trivalent metal selected from the group consisting of Al, Sc, Ga, Y, and In, and m is 1. Y represents the following atomic group:

[Chem. 25]



[0095] In the chemical structure of the atomic group Y, the central metal M is the same as defined above, and X^{17i} to X^{32i} are the same as the above-described definition of X^{1i} to X^{16i} in General Formula (PIG-1). A represents a divalent atomic group selected from the group consisting of an oxygen atom, a sulfur atom, a sulfinyl (-SO-), and a sulfonyl ($-SO_2-$). M of General Formula (PIG-1) and M of the atomic group Y are bonded to each other via the divalent atomic group A.

[0096] In other words, the halogenated metal phthalocyanine pigments belonging to Group 2 are halogenated metal phthalocyanine dimers having a structural unit constituted by two halogenated metal phthalocyanine molecules bonded to each other via the divalent atomic group.

[0097] Specific examples of the halogenated metal phthalocyanine pigments represented by General Formula (PIG-1) include (1) to (4) described below.

(1) Halogenated metal phthalocyanine pigments including a divalent metal selected from the group consisting of Mg, Fe, Co, Ni, Zn, Cu, Zr, Sn, and Pb as a central metal, in which 8 to 16 halogen atoms are bonded to 4 benzene rings per phthalocyanine molecule, such as a halogenated copper phthalocyanine pigment, a halogenated tin phthalocyanine pigment, a halogenated nickel phtalocyanine pigment, and a halogenated zinc phtalocyanine pigment. Among such pigments, in particular, a chlorinated and brominated zinc phtalocyanine pigment, that is, C.I. Pigment Green 58, is preferably used.

(2) Halogenated metal phthalocyanine pigments including a trivalent metal selected from the group consisting of Al, Sc, Ga, Y, and In as a central metal, in which one group selected from a halogen atom, a hydroxyl group, and a sulfonic group is bonded to the central metal and 8 to 16 halogen atoms are bonded to 4 benzene rings per phthalocyanine molecule, such as halogenated chloroaluminum phthalocyanine.

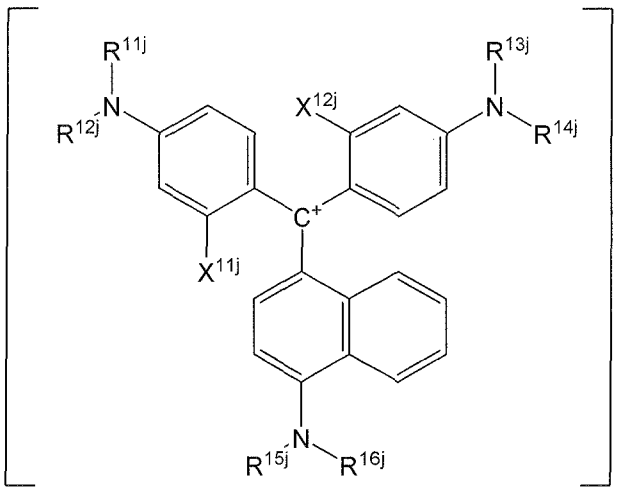
(3) Halogenated metal phthalocyanine pigments including a tetravalent metal selected from the group consisting of Si, Ti, V, Ge, Zr, and Sn as a central metal, in which one oxygen atom or two identical or different groups selected from a halogen atom, a hydroxyl group, and a sulfonic group are bonded to the central metal and 8 to 16 halogen atoms are bonded to 4 benzene rings per phthalocyanine molecule, such as halogenated oxytitanium phthalocyanine and halogenated oxyvanadium phthalocyanine.

(4) Pigments that are halogenated metal phthalocyanine dimers having a structural unit constituted by two halogenated metal phthalocyanine molecules including a trivalent metal selected from the group consisting of Al, Sc, Ga, Y, and In as a central metal and 8 to 16 halogen atoms bonded to 4 benzene rings per phthalocyanine molecule, the central metals in the structural unit being bonded to each other via a divalent atomic group selected from the group consisting of an oxygen atom, a sulfur atom, sulfinyl, and sulfonyl, such as a halogenated μ-oxo-aluminium phthalocyanine dimer and a halogenated μ-thio-aluminium phthalocyanine dimer.

[0098] Specifically, the halogenated metal phthalocyanine pigment included in the G pixel portion is preferably one or more pigments selected from C.I. Pigment Green 7, C.I. Pigment Green 36, and C.I. Pigment Green 58 and is more preferably one or more pigments selected from C.I. Pigment Green 36 and C.I. Pigment Green 58.

[0099] The ε-type phthalocynian pigment included in the B pixel portion is preferably C.I. Pigment Blue 15:6. The triarylmethane pigment included in the B pixel portion is preferably C.I. Pigment Blue 1 and/or a triarylmethane pigment represented by General Formula (1) below:

[Chem. 26]



(1)

[0100] (in General Formula (1), R^{11j} to R^{16j} each independently represent a hydrogen atom, an alkyl group having 1 to 8 carbon atoms which may be substituted, or an aryl group which may be substituted; when R^{11j} to R^{16j} represent an alkyl group which may be substituted, adjacent R^{11j} and R^{12j}, adjacent R^{13j} and R^{14j}, and adjacent R^{15j} and R^{16j} may be bonded to each other to form a ring structure; X^{11j} and X^{12j} each independently represent a hydrogen atom, a halogen atom, or an alkyl group having 1 to 8 carbon atoms which may be substituted; Z^- is at least one anion selected from a heteropolyoxometalate anion represented by $(P_2Mo_yW_{18-y}O_{62})^{6-}/6$ where y is an integer of 0, 1, 2, or 3, a heteropolyoxometalate anion represented by $(SiMoW_{11}O_{40})^{4-}/4$, and a lacunary Dawson-type phosphotungstic acid heteropolyoxometalate anion; and, when one molecule includes a plurality of structures represented by Formula (1), the structures may be identical or different).

[0101] In General Formula (1), R^{11j} to R^{16j} may be identical or different. Thus, -NRR (RR represents any one combination of $R^{11j}R^{12j}$, $R^{13j}R^{14j}$, and $R^{15j}R^{16j}$) group may be symmetrical or asymmetrical.

[0102] When adjacent R's (R represents any one of R^{11j} to R^{16j}) are bonded to each other to form a ring, the ring may be formed by cross-linking of hetero atoms. Specific examples of such a ring include the following rings, which may be substituted:

[Chem. 27]

[0103] R^{11j} to R^{16j} are preferably each independently a hydrogen atom, an alkyl group which may be substituted, or an aryl group which may be substituted from the viewpoint of chemical stability.

[0104] In particular, R^{11j} to R^{16j} are more preferably each independently a hydrogen atom; an alkyl group such as a methyl group, an ethyl group, a propyl group, an isopropyl group, a cyclopropyl group, a butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, a cyclopentyl group, a hexyl group, a cyclohexyl group, a heptyl group, an octyl group, or a 2-ethylhexyl group; or an aryl group such as a phenyl group or a naphthyl group.

[0105] When R^{11j} to R^{16j} represent an alkyl group or an aryl group, the alkyl group or the aryl group may further include an optional substituent. Examples of the optional substituent that can be included in the alkyl group or the aryl group include the following [Substituent Group Y].

[Substituent Group Y]

[0106] Alkyl groups such as a methyl group, an ethyl group, a propyl group, an isopropyl group, a cyclopropyl group, a butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, a pentyl group, a cyclopentyl group, a hexyl group,

a cyclohexyl group, a heptyl group, an octyl group, and a 2-ethylhexyl group; aryl groups such as a phenyl group and a naphthyl group; halogen atoms such as a fluorine atom and a chlorine atom; a cyano group; a hydroxyl group; alkoxy groups having 1 to 8 carbon atoms, such as a methoxy group, an ethoxy group, a propoxy group, and a butoxy group; amino groups which may be substituted, such as an amino group, a diethylamino group, a dibutylamino group, and an acetylamino group; acyl groups such as an acetyl group and a benzoyl group; and acyloxy groups such as an acetyloxy group and a benzoyloxy group.

[0107] R^{11j} to R^{16j} are further preferably an alkyl group having 1 to 8 carbon atoms which may be substituted, that is, more specifically, any one of the following alkyl groups: alkyl groups which is not substituted, such as a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a sec-butyl group, a pentyl group, a hexyl group, and a 2-ethylhexyl group; alkoxyalkyl groups such as a 2-methoxyethyl group and a 2-ethoxyethyl group; acyloxy groups such as a 2-acetyloxyethyl group; cyanoalkyl groups such as a 2-cyanoethyl group; and fluoroalkyl groups such as a 2,2,2-trifluoroethyl group and a 4,4,4-trifluorobutyl group.

[0108] When X^{11j} and X^{12j} are any one of these alkyl groups, X^{11j} and X^{12j} may further include an optional substituent. Examples of the optional substituent include halogen atoms such as a fluorine atom, a chlorine atom, a bromine atom, and an iodine atom; and alkoxy groups such as a methoxy group, an ethoxy group, and a propoxy group. Specific examples of X^{11j} and X^{12j} include haloalkyl groups such as a fluoromethyl group, a trifluoromethyl group, a trichloromethyl group, and a 2,2,2-trifluoroethyl group; and alkoxyalkyl groups such as a methoxymethyl group.

[0109] X^{11j} and X^{12j} are preferably a substituent that causes an appropriate degree of steric hindrance which does not affect torsion to occur, such as a hydrogen atom, a methyl group, a chlorine atom, or a trifluoromethyl group. X^{11j} and X^{12j} are most preferably a hydrogen atom, a methyl group, or a chlorine atom from the viewpoints of color tone and heat resistance.

[0110] Z^- is at least one anionic triarylmethane compound selected from a heteropolyoxometalate anion represented by $(P_2Mo_yW_{18-y}O_{62})^{6-}/6$, where y is an integer of 0, 1, 2, or 3; a heteropolyoxometalate anion represented by $(SiMoW_{11}O_{40})^{4-}/4$; and a lacunary Dawson-type phosphotungstic acid heteropolyoxometalate anion. Specifically, the lacunary Dawson-type phosphotungstic acid is preferably a 1-lacunary Dawson-type phosphotungstic acid heteropolyoxometalate anion $(P_2W_{17}O_{61})^{10-}/10$ from the viewpoint of durability.

[0111] Specific examples of the triarylmethane pigment represented by General Formula (1) include the compounds shown in Tables 1 to 7 below. However, the present invention is not limited to these compounds as long as the idea of the present invention is not impaired.

[Table 1]

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z^-
1	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	H	(P2W18O62)6-
2	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	H	(P2MoW17O62)6-
3	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	H	(P2Mo2W16O62)6-
4	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	H	(P2Mo3W15O62)6-
5	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	H	(SiMoW11O40)4-
6	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	H	(P2W17O61)10-
7	CH3-	CH3-	CH3-	CH3-	C2H5-	H	H	H	(P2W18O62)6
8	CH3-	CH3-	CH3-	CH3-	C2H5-	H	H	H	(P2MoW17O62)6-
9	CH3-	CH3-	CH3-	CH3-	C2H5-	H	H	H	(P2Mo3W15O62)6-

[Table 2]

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z-
10	CH3-	CH3-	CH3-	CH3-	C2H5-	H	H	H	(P2Mo3W15O62)6
11	CH3-	CH3-	CH3-	CH3-	C2H5-	H	H	H	(SiMoW11O40)4-
12	CH3-	CH3-	CH3-	CH3-	C2H5-	H	H	H	(P2W 17061) 10-
13	CH3-	CH3-	CH3-	CH3-	Ph-	H	H	H	(P2W18O62)6-
14	CH3-	CH3-	CH3-	CH3-	Ph-	H	H	H	(P2MoW17O62)6-

(continued)

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z-
15	CH3-	CH3-	CH3-	CH3-	Ph-	H	H	H	(P2Mo2W16O62)6-
16	CH3-	CH3-	CH3-	CH3-	Ph-	H	H	H	(P2Mo3W15O62)6-
17	CH3-	CH3-	CH3-	CH3-	Ph-	H	H	H	(SiMoW11O40)4-
18	CH3-	CH3-	CH3-	CH3-	Ph-	H	H	H	(P2W17O61)10-

[Table 3]

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z-
19	CH3-	CH3-	CH3-	CH3-	Ph-	CH3-	H	H	(P2W18O62)6-
20	CH3-	CH3-	CH3-	CH3-	Ph-	CH3-	H	H	(P2MoW17O62)6-
21	CH3-	CH3-	CH3-	CH3-	Ph-	CH3-	H	H	(P2Mo2W16O62)6-
22	CH3-	CH3-	CH3-	CH3-	Ph-	CH3-	H	H	(P2Mo3W15O62)6-
23	CH3-	CH3-	CH3-	CH3-	Ph-	CH3-	H	H	(SiMoW11O40)4-
24	CH3-	CH3-	CH3-	CH3-	Ph-	CH3-	H	H	(P2W17O61)10-
25	n-C3H7-	n-C3H7-	n-C3H7-	n-C3H7-	C2H5-	H	H	H	(P2W18O62)6-
26	n-C3H7-	n-C3H7-	n-C3H7-	n-C3H7-	C2H5-	H	H	H	(P2MoW17O62)6-
27	n-C3H7-	n-C3H7-	n-C3H7-	n-C3H7-	C2H5-	H	H	H	(P2Mo2W16O62)6-

[Table 4]

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z-
28	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	H	(P2W18O62)6-
29	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	H	(P2MoW17O62)6-
30	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	H	(P2Mo2W16O62)6-
31	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	H	(P2Mo3W15O62)6-
32	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	H	(SiMoW11O40)4-
33	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	H	(P2W17O61)10-
34	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	CH3-	(P2W18O62)6
35	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	CH3-	(P2MoW17O62)6-
36	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	CH3-	(P2Mo3W15O62)6-

[Table 5]

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z-
37	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	CH3-	(P2Mo3W15O62)6-
38	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	CH3-	(SiMoW11O40)4-
39	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	CH3-	CH3-	(P2W17O61)10-
40	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	Cl	H	(P2W18O62)6-
41	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	Cl	H	(P2MoW17O62)6-
42	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	Cl	H	(P2Mo2W16O62)6-

(continued)

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z^-
43	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	Cl	H	(P2Mo3W15O62)6-
44	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	Cl	H	(SiMoW11O40)4-
45	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	Cl	H	(P2W17O61)10-

[Table 6]

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z^-
46	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	(P2W18O62)6-
47	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	(P2MoW17O62)6-
48	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	(P2Mo2W16O62)6-
49	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	(P2Mo3W15O62)6-
50	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	(SiMoW11O40)4-
51	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	C2H5-	H	H	(P2W17O61)10-
52					C2H5-	H	H	H	(P2W18O62)6-
53					C2H5-	H	H	H	(P2MoW17O62)6-
54					C2H5-	H	H	H	(P2Mo2W16O62)6-

[Table 7]

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z^-
55					C2H5-	H	H	H	(P2Mo3W15O62)6-
56					C2H5-	H	H	H	(SiMoW11O40)4-
57					C2H5-	H	H	H	(P2W17O61)10-
58	4,4,4-trifluorobutyl	4,4,4-trifluorobutyl	C2H5-	C2H5-	C2H5-	H	H	H	(P2W18O62)6-
59	4,4,4-trifluorobutyl	4,4,4-trifluorobutyl	C2H5-	C2H5-	C2H5-	H	H	H	(P2MoW17O62)6-
60	4,4,4-trifluorobutyl	4,4,4-trifluorobutyl	C2H5-	C2H5-	C2H5-	H	H	H	(SiMoW11O40)4-
61	4,4,4-trifluorobutyl	4,4,4-trifluorobutyl	C2H5-	C2H5-	C2H5-	H	CH3-	H	(P2W18O62)6-

(continued)

No.	R^{11j}	R^{12j}	R^{13j}	R^{14j}	R^{15j}	R^{16j}	X^{11j}	X^{12j}	Z^-
62	4,4,4-trifluorobutyl	4,4,4-trifluorobutyl	C2H5-	C2H5-	C2H5-	H	CH3	H	(P2MoW17O62)6-
63	4,4,4-trifluorobutyl	4,4,4-trifluorobutyl	C2H5-	C2H5-	C2H5-	H	CH3	H	((SiMoW11O40)4-

[0112] The R pixel portion of the RGB three-color pixel portions preferably further includes, as a coloring material, at least one organic pigment selected from the group consisting of C.I. Pigment Red 177, C.I. Pigment Red 242, C.I. Pigment Red 166, C.I. Pigment Red 167, C.I. Pigment Red 179, C.I. Pigment Orange 38, C.I. Pigment Orange 71, C.I. Pigment Yellow 150, C.I. Pigment Yellow 215, C.I. Pigment Yellow 185, C.I. Pigment Yellow 138, and C.I. Pigment Yellow 139.

[0113] The G pixel portion of the RGB three-color pixel portions preferably further includes, as a coloring material, at least one organic pigment selected from the group consisting of C.I. Pigment Yellow 150, C.I. Pigment Yellow 215, C.I. Pigment Yellow 185, and C.I. Pigment Yellow 138.

[0114] The B pixel portion of the RGB three-color pixel portions preferably further includes, as a coloring material, at least one organic dye or pigment selected from the group consisting of C.I. Pigment Blue 1 and C.I. Pigment Violet 23.

[0115] In the case where the color filter is constituted by a black matrix, RGB three-color pixel portions, and a Y pixel portion, the Y pixel portion preferably includes, as a coloring material, a pigment having a water-soluble content of 1.5% or less and/or a specific electrical conductivity of 150 μS/cm or less. The water-soluble content of the pigment is more preferably 1.0% or less. The specific electrical conductivity of the pigment is more preferably 100 μS/cm or less. It is more preferable that the water-soluble content of the pigment is 1.0% or less and the specific electrical conductivity of the pigment is 100 μS/cm or less.

[0116] The Y pixel portion preferably includes, as a coloring material, at least one yellow organic dye or pigment selected from the group consisting of C.I. Pigment Yellow 150, C.I. Pigment Yellow 215, C.I. Pigment Yellow 185, C.I. Pigment Yellow 138, and C.I. Pigment Yellow 139.

[0117] The chromaticity of each of the above-described pixel portions can be controlled by changing the types of the dyes and pigments used or the mixing ratio of the dyes and pigments. For example, the chromaticity of an R pixel can be controlled by adding a yellow dye or pigment and/or an orange pigment to a red dye or pigment in an appropriate amount, the chromaticity of a G pixel can be controlled by adding a yellow dye or pigment to a green dye or pigment in an appropriate amount, and the chromaticity of a B pixel can be controlled by adding a purple dye or pigment to a blue dye or pigment in an appropriate amount. The chromaticity of the pixels can also be controlled by appropriately changing the diameter of the particles of a pigment.

[0118] The pixel portions of the color filter may be formed by a publicly known method. A common method for forming pixel portions is photolithography. In photolithography, the photo-curable composition described below is applied to a surface of a transparent substrate for color filters on which a black matrix is disposed and then dried by being heated (pre-baked). Subsequently, the surface of the transparent substrate is irradiated with ultraviolet rays through a photomask to perform pattern exposure to cure portions of the photo-curable compound corresponding to pixel portions. Unexposed portions are developed with a developing solution. Non-pixel portions are removed, and the pixel portions are fixed on the transparent substrate. In this method, pixel portions formed of a cured, colored coating film composed of the photo-curable composition are formed on the transparent substrate.

[0119] For each colored pixels of R pixels, G pixels, B pixels, and, as needed, other color pixels such as Y pixels, the photo-curable compositions described below are prepared and the above-described operations are repeated. Thus, a color filter including colored pixel portions of R pixels, G pixels, B pixels, and Y pixels formed at the respective predetermined positions can be produced.

[0120] Spin coating, roll coating, an ink-jet method, and the like can be employed for applying the photo-curable composition described below to a transparent substrate composed of glass or the like.

[0121] The conditions for drying the coating film composed of the photo-curable composition applied to a transparent substrate vary depending on, for example, the types of and proportions of the constituents of the photo-curable composition, but are generally at 50°C to 150°C for about 1 to about 15 minutes. Light used for photo-curing of the photo-curable composition is preferably ultraviolet rays in the wavelength range of 200 to 500 nm or visible light. Any light source that emits light in this wavelength range can be used.

[0122] Examples of a developing method include a liquid application method, a dipping method, and a spraying method. After the exposure and development of the photo-curable composition, the transparent substrate on which the pixel portions of the desired colors are formed is washed with water and then dried. The resulting color filter is subjected to

a heat treatment (post-baking) at 90°C to 280°C for a predetermined time using a heating device such as a hot plate or an oven. This removes volatile constituents contained in the colored coating film and causes an unreacted portion of the photo-curable compound remaining in the cured, colored coating film composed of the photo-curable composition to heat-cure. Thus, a color filter is formed.

[0123] By using the coloring material for color filters according to the present invention in combination with the liquid crystal composition according to the present invention, a liquid crystal display apparatus that limits a reduction in the voltage holding ratio (VHR) of the liquid crystal layer and limits an increase in the ion density (ID) of the liquid crystal layer, which addresses faulty display issues such as white missing pixels, alignment inconsistencies, and burn-in, can be provided.

[0124] In general, the photo-curable composition can be prepared in the following manner. Essential components, that is, the dye and/or pigment composition for color filters according to the present invention, an organic solvent, and a dispersing agent are mixed together, and the resulting mixture is stirred so as to uniformly disperse these components. Thus, a pigment dispersion used for forming pixel portion of a color filter is prepared. Then, a photo-curable compound and, as needed, a thermoplastic resin, a photopolymerization initiator, and the like are added to the pigment dispersion. Thus, the photo-curable composition is prepared.

[0125] Examples of the organic solvent used above include aromatic compound solvents such as toluene, xylene, and methoxybenzene; acetic acid ester solvents such as ethyl acetate, propyl acetate, butyl acetate, propylene glycol monomethyl ether acetate, propylene glycol monoethyl ether acetate, diethylene glycol methyl ether acetate, diethylene glycol ethyl ether acetate, diethylene glycol propyl ether acetate, and diethylene glycol butyl ether acetate; propionate solvents such as ethoxyethyl propionate; alcohol solvents such as methanol and ethanol; ether solvents such as butyl cellosolve, propylene glycol monomethyl ether, diethylene glycol ethyl ether, and diethylene glycol dimethyl ether; ketone solvents such as methyl ethyl ketone, methyl isobutyl ketone, and cyclohexanone; aliphatic hydrocarbon solvents such as hexane; nitrogen compound solvents such as N,N-dimethylformamide, γ-butyrolactam, N-methyl-2-pyrrolidone, aniline, and pyridine; lactone solvents such as γ-butyrolactone; and carbamic acid ester such as a 48:52 mixture of methyl carbamate and ethyl carbamate.

[0126] Examples of the dispersing agent used above include DISPERBYK 130, DISPERBYK 161, DISPERBYK 162, DISPERBYK 163, DISPERBYK 170, DISPERBYK 171, DISPERBYK 174, DISPERBYK 180, DISPERBYK 182, DISPERBYK 183, DISPERBYK 184, DISPERBYK 185, DISPERBYK 2000, DISPERBYK 2001, DISPERBYK 2020, DISPERBYK 2050, DISPERBYK 2070, DISPERBYK 2096, DISPERBYK 2150, DISPERBYK LPN21116, and DISPERBYK LPN6919 produced by BYK-Chemie; EFKA 46, EFKA 47, EFKA 452, EFKA LP4008, EFKA 4009, EFKA LP4010, EFKA LP4050, LP4055, EFKA 400, EFKA 401, EFKA 402, EFKA 403, EFKA 450, EFKA 451, EFKA 453, EFKA 4540, EFKA 4550, EFKA LP4560, EFKA 120, EFKA 150, EFKA 1501, EFKA 1502, and EFKA 1503 produced by EFKA; Solsperse 3000, Solsperse 9000, Solsperse 13240, Solsperse 13650, Solsperse 13940, Solsperse 17000, 18000, Solsperse 20000, Solsperse 21000, Solsperse 20000, Solsperse 24000, Solsperse 26000, Solsperse 27000, Solsperse 28000, Solsperse 32000, Solsperse 36000, Solsperse 37000, Solsperse 38000, Solsperse 41000, Solsperse 42000, Solsperse 43000, Solsperse 46000, Solsperse 54000, and Solsperse 71000 produced by Lubrizol Corporation; and AJISPER PB711, AJISPER PB821, AJISPER PB822, AJISPER PB814, AJISPER PN411, and AJISPER PA111 produced by Ajinomoto Co., Inc. In addition, synthetic resins that are insoluble in water and liquid at room temperature may also be used. Examples of such synthetic resins include an acrylic resin; a urethane resin; an alkyd resin; natural rosins such as a wood rosin, a gum rosin, and a tall rosin; modified rosins such as a polymerized rosin, a disproportionated rosin, a hydrogenated rosin, an oxidized rosin, and a maleated rosin; and rosin derivatives such as a rosin amine, a lime rosin, alkylene oxide adducts of a rosin, alkyd adducts of a rosin, and a rosin-modified phenol. Addition of the above-described dispersing agents and the above-described resins also contributes to reduction in flocculation, improvement of the dispersion stability of the pigments, and improvement of the viscometric property of the dispersion solutions.

[0127] An organic pigment derivative such as a phthalimidemethyl derivative, a sulfonic acid derivative, an N-(dialkylamino)methyl derivative, or an N-(dialkylaminoalkyl)sulfonic acid amide derivative may also be added as a dispersing aid. Needless to say, two or more different types of these derivatives may be used in combination.

[0128] Examples of the thermoplastic resin used for preparing the photo-curable composition include a urethane resin, an acrylic resin, a polyamide resin, a polyimide resin, a styrene-maleic acid-based resin, and a styrene-maleic anhydride-based resin.

[0129] Examples of the photo-curable compound include difunctional monomers such as 1,6-hexanediol diacrylate, ethylene glycol diacrylate, neopentyl glycol diacrylate, triethylene glycol diacrylate, bis(acryloxyethoxy)bisphenol A, and 3-methylpentanediol diacrylate; multifunctional monomers having a relatively low molecular weight, such as trimethylolpropatone triacrylate, pentaerythritol triacrylate, tris[2-(meth)acryloyloxyethyl]isocyanurate, dipentaerythritol hexaacrylate, and dipentaerythritol pentaacrylate; and multifunctional monomers having a relatively high molecular weight, such as polyester acrylate, polyurethane acrylate, and polyether acrylate.

[0130] Examples of the photopolymerization initiator include acetophenone, benzophenone, benzildimethylketanol, benzoyl peroxide, 2-chlorothioxanthone, 1,3-bis(4'-azidobenzal)-2-propane, 1,3-bis(4'-azidobenzal)-2-propane-2'-sul-

fonic acid, and 4,4'-diazidostilbene-2,2'-disulfonic acid. Examples of commercially available photopolymerization initiators include "Irgacure (trade name)-184", "Irgacure (trade name)-369", "Darocur (trade name)-1173", and "Lucirin-TPO" produced by BASF, "KAYACURE (trade name) DETX" and "KAYACURE (trade name) OA" produced by Nippon Kayaku Co., Ltd., "Vicure 10" and "Vicure 55" produced by Stauffer Chemical Co., "Trigonal PI" produced by Akzo Nobel N.V., "Sandrey 1000" produced by Sand, "Deep" produced by Upjohn Company, and "Biimidazole" produced by KUROGANE KASEI Co., Ltd.

[0131] Publicly known, commonly used photosensitizers may be used in combination with the above-described photopolymerization initiators. Examples of the photosensitizers include amines, ureas, compounds containing a sulfur atom, compounds containing a phosphorus atom, compounds containing a chlorine atom, nitriles, and other compounds containing a nitrogen atom. These compounds may be used alone or in combination of two or more.

[0132] The mixing proportion of the photopolymerization initiator is preferably, but is not particularly limited to, 0.1% to 30% by mass relative to the amount of compounds including a photo-polymerizable or photo-curable functional group. If the mixing proportion of the photopolymerization initiator is less than 0.1%, the photographic sensitivity during photocuring may decrease. If the mixing proportion of the photopolymerization initiator exceeds 30%, the crystal of the photopolymerization initiator may precipitate when a pigment-dispersed resist coating film is dried, which may deteriorate the physical properties of the coating film.

[0133] Using the above-described materials, by mass, 100 parts of the dye and/or pigment composition for color filters according to the present invention is mixed with 300 to 1000 parts of an organic solvent and 1 to 100 parts of a dispersing agent, and the resulting mixture is stirred so as to uniformly disperse the components. Thus, the above-described dye and pigment liquid can be prepared. Subsequently, a thermoplastic resin, a photo-curable compound, a photopolymerization initiator, and, as needed, an organic solvent are added to the pigment dispersion in such a manner that the total amount of the thermoplastic resin and the photo-curable compound is 3 to 20 parts relative to 1 part of the pigment composition for color filters according to the present invention and the amount of the photopolymerization initiator is 0.05 to 3 parts relative to 1 part of the photo-curable compound. The resulting mixture is stirred so as to uniformly disperse the above components. Thus, a photo-curable composition for forming pixel portions of the color filter is prepared.

[0134] Publicly known and commonly used organic solvents and aqueous alkaline solutions may be used as a developing solution. In particular, when the photo-curable composition includes a thermoplastic resin or a photo-curable compound and at least one of them has an acid value and alkali-solubility, washing with an aqueous alkaline solution may be effective in forming pixel portions of the color filter.

[0135] A method for producing pixel portions of the color filter by photolithography is described above in detail. Alternatively, the pixel portions of the color filter, which are prepared using the pigment composition for color filters according to the present invention, may be formed by another method such as an electrodeposition method, a transfer method, a micelle electrolysis method, a PVED (photovoltaic electrodeposition) method, an ink-jet method, a reverse printing method, or a thermosetting method. The pixel portions are formed for each color to produce a color filter.

(Alignment Film)

[0136] In the liquid crystal display apparatus according to the present invention, when an alignment film is provided in order to align a liquid crystal composition, the alignment film is disposed between the color filter and the liquid crystal layer on a surface of the first substrate and a surface of the second substrate which are brought into contact with the liquid crystal composition. The thickness of the alignment film is small, that is, 100 nm or less at most. Thus, the alignment film does not completely block the interaction between coloring agents such as pigments constituting the color filter and a liquid crystal compound constituting the liquid crystal layer.

[0137] In a liquid crystal display apparatus that does not include the alignment film, the interaction between coloring agents, such as pigments, constituting the color filter and a liquid crystal compound constituting the liquid crystal layer becomes stronger.

[0138] The alignment film may be composed of, for example, a transparent organic material such as polyimide, polyamide, BCB (benzocyclobutene polymer), or polyvinyl alcohol. In particular, a polyimide alignment film formed by imidization of a polyamic acid prepared by synthesizing a diamine such as an aliphatic or alicyclic diamine (e.g., p-phenylenediamine or 4,4'-diaminodiphenylmethane) with an aliphatic or alicyclic tetracarboxylic acid anhydride (e.g., butanetetracarboxylic acid anhydride or 2,3,5-tricarboxycyclopentyl acetic acid anhydride) or with an aromatic tetracarboxylic acid anhydride (e. g., pyromellitic dianhydride) is preferably used. In this case, generally, alignment is performed by rubbing. When the film serves as a vertical alignment film or the like, alignment is not necessarily performed.

[0139] The alignment film may be composed of a material including chalcone, cinnamate, cinnamoyl, or an azo group in the compound. Such a material can be used in combination with polyimide, polyamide, or the like. In such a case, the alignment film may be formed by rubbing or using a photo-alignment technology.

[0140] In order to form the alignment film, in general, the above-described material of the alignment film is applied to a substrate by spin coating to form a resin film. Alternatively, a uniaxial stretching method, the Langmuir-Blodgett method,

and the like may be employed.

(Transparent Electrode)

[0141] In the liquid crystal display apparatus according to the present invention, the transparent electrode may be composed of a conductive metal oxide. Examples of the metal oxide include indium oxide (In_2O_3), tin oxide (SnO_2), zinc oxide (ZnO), indium tin oxide (In_2O_3-SnO_2), indium zinc oxide (In_2O_3-ZnO), niobium-doped titanium dioxide ($Ti_{1-x}Nb_xO_2$), fluorine-doped tin oxide, graphene nanoribbon, and metal nanowire. Zinc oxide (ZnO), indium tin oxide (In_2O_3-SnO_2), and indium zinc oxide (In_2O_3-ZnO) are preferably used. These transparent conductive films can be patterned by, for example, photo-etching or using a mask.

EXAMPLES

[0142] A part of the preferred embodiment of the present invention is described below in detail with reference to Examples, which do not limit the present invention. When referring to a composition in Examples and Comparative Examples, "%" always denotes "% by mass".

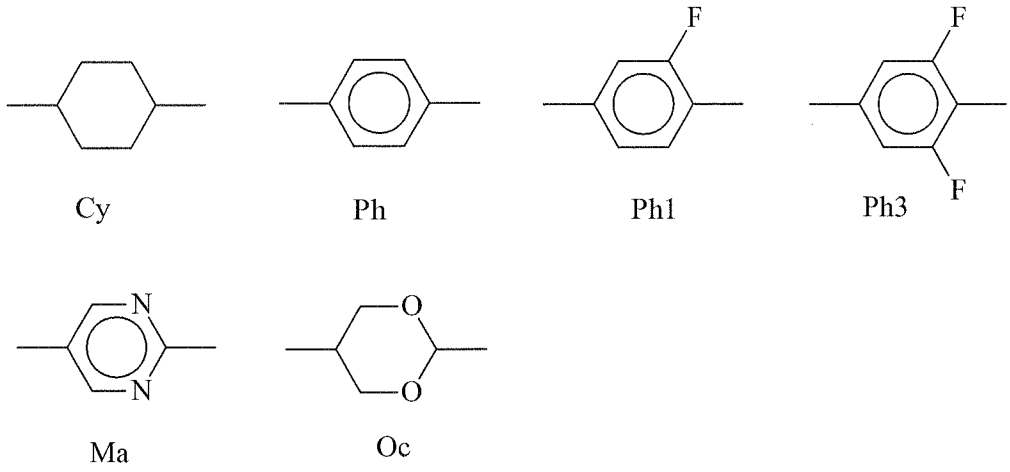
[0143] The physical properties of a liquid crystal composition are represented as follows.

T_{N-I}: Nematic phase-isotropic liquid phase transition temperature (°C) as an upper limit temperature of liquid crystal phase
$\Delta\varepsilon$: Dielectric anisotropy
Δn: Refractive index anisotropy
η: Viscosity (mPa·s) at 20°C
d_{gap}: Gap (μm) between a first substrate and a second substrate of a cell
VHR: Voltage holding ratio (%) at 70°C
(the ratio (%) of a voltage measured when a voltage of 5 V was applied to a cell having a thickness of 3.5 μm, in which the liquid crystal composition had been injected, at a frame time of 200 ms and a pulse width of 64 μs relative to the initially applied voltage)
ID: Ion density (pC/cm^2) at 70°C
(an ion density measured with MTR-1 (produced by TOYO Corporation) when a voltage of 20 V was applied to a cell having a thickness of 3.5 μm, in which the liquid crystal composition had been injected, at a frequency of 0.05 Hz)

[0144] The following abbreviations are used to describe compounds.

n (numeral) at the end	C_nH_{2n+1}-
-2-	$-CH_2CH_2-$
-1O-	$-CH_2O-$
-O1-	$-OCH_2-$
-V-	-CO-
-VO-	-COO-
-CFFO-	$-CF_2O-$
-F	-F
-Cl	-Cl
-CN	-C=N
-OCFFF	$-OCF_3$
-CFFF	$-CF_3$
-OCFF	$-OCHF_2$
-On	$-OC_nH_{2n+1}$
-T-	-C≡C-
ndm-	C_nH_{2n+1}-HC=CH-$(CH_2)_{m-1}$-

[Chem. 28]



[0145] The liquid crystal display apparatus was evaluated in terms of burn-in in the following manner. A predetermined fixed pattern was displayed in a displaying area for 1000 hours. Subsequently, uniform display over the entire screen was performed, and the level of a residual image of the fixed pattern was visually inspected and rated on the following four-point scale.

Excellent: A residual image was absent.
Good: A slight residual image was present, but at an acceptable level.
Poor: A residual image was present at an unacceptable level.
Failure: A strong residual image was present.

[Preparation of Color Filter]

[Preparation of Coloring Composition]

[Red Pigment Coloring Composition 1]

[0146] Into a plastic bottle, 10 parts of a red pigment 1 (C.I. Pigment Red 254, water-soluble content: 0.3%, specific electrical conductivity: 30 μS/cm) was charged. Into the plastic bottle, 55 parts of propylene glycol monomethyl ether acetate, 7.0 parts of DISPERBYK LPN21116 (produced by BYK-Chemie), and 0.3-to-0.4-mmϕ SEPR beads were added. These components were dispersed for 4 hours using Paint Conditioner (produced by Toyo Seiki Kogyo Co., Ltd.). The resulting mixture was filtered through a 5-μm filter to prepare a pigment dispersion. Then, 75.00 parts of the pigment dispersion was mixed with 5.50 parts of a polyester acrylate resin (ARONIX (trade name) M7100, produced by TOAGOSEI CO., LTD.), 5.00 parts of dipentaerythritol hexaacrylate (KAYARAD (trade name) DPHA, produced by Nippon Kayaku Co., Ltd.), 1.00 parts of benzophenone (KAYACURE (trade name) BP-100, produced by Nippon Kayaku Co., Ltd.), and 13.5 parts of UCAR ester EEP under stirring using a dispersion stirrer. The resulting mixture was filtered through a filter having a pore size of 1.0 μm. Thus, a red pigment coloring composition 1 was prepared.

[0147] Note that the water-soluble content of the pigment was calculated in accordance with JIS K5101-16-1 (Test methods for pigments-Part 16: Matter soluble in water-Section 1: Hot extraction method), that is, in the following manner:

1. Into a 500-mL rigid beaker, 5.00 g of an accurately weighed pigment is charged. To the beaker, 200 mL of ion-exchange water (electrical conductivity: 5 μS/cm or less, pH: 7.0 ± 1.0) is added. The ion-exchange water is added in small amounts at a time. After 5 mL of first-grade reagent methanol is added to the beaker to soak the pigment in the ion-exchange water to a sufficient degree, the remaining ion-exchange water is added to the beaker. The resulting liquid mixture is boiled for 5 minutes.
2. The liquid mixture is cooled to room temperature, and transferred to a 250-mL graduated cylinder. To the graduated cylinder, the above-described ion-exchange water is added until the volume of the liquid mixture becomes 250 mL. The liquid mixture is vigorously stirred and then filtered through a filter paper No. 5C produced by ADVANTEC.
3. Initially, about 50 mL of the filtrate is removed, and 100 mL of the remaining filtrate is weighed using a graduated cylinder and transferred to an evaporation pan of known mass. The filtrate adhering to the graduated cylinder is washed off with a small amount of ion-exchange water into the evaporation pan.
4. The evaporation pan is placed in a water bath, and evaporation to dryness is performed. The evaporation pan is

dried for 2 hours in a drying machine kept at 105°C to 110°C and subsequently charged into a desiccator. After the evaporation pan is left to cool, the mass of the evaporation pan is measured. Thus, the amount of substance that remained after evaporation is determined.

5. The water-soluble content of the pigment is calculated using the following formula.

$$\text{Water-soluble content of the pigment (\%)} = \text{Amount of substance remaining after evaporation (g)} \times 2.5 / \text{Mass of the pigment (g)} \times 100$$

[0148] The specific electrical conductivity of the pigment was calculated in the following manner. The specific electrical conductivity of the ion-exchange water used was measured using a conductivity meter (e.g., Model: CM-30V produced by DKK-TOA CORPORATION). The specific electrical conductivity of the 100 mL of filtrate, which was weighed using a graduated cylinder in the above step 3, was measured using the conductivity meter. Then, the specific electrical conductivity of the pigment was calculated by correcting the measured value by using the following formula.

[0149] Specific electrical conductivity of the pigment = Specific electrical conductivity of the filtrate - Specific electrical conductivity of the ion-exchange water used

[Red Pigment Coloring Composition 2]

[0150] A red pigment coloring composition 2 was prepared as described above, except that a pigment (water-soluble content: 0.4%, specific electrical conductivity: 30 μS/cm) prepared by mixing 6 parts of the red pigment 1 with 2 parts of a red pigment 2 (C.I. Pigment Red 177, water-soluble content: 0.5%, specific electrical conductivity: 40 μS/cm) and 2 parts of a yellow pigment 1 (C.I. Pigment Yellow 139, water-soluble content: 0.4%, specific electrical conductivity: 40 μS/cm) was used instead of 10 parts of the red pigment 1 used for preparing the red pigment coloring composition 1.

[Red Pigment Coloring Composition 3]

[0151] A red pigment coloring composition 3 was prepared as described above, except that 10 parts of a red pigment 3 (C.I. Pigment Red 255, water-soluble content: 0.6%, specific electrical conductivity: 60 μS/cm) was used instead of 10 parts of the red pigment 1 used for preparing the red pigment coloring composition 1.

[Red Pigment Coloring Composition 4]

[0152] A red pigment coloring composition 4 was prepared as described above, except that a pigment (water-soluble content: 0.2%, specific electrical conductivity: 30 μS/cm) prepared by mixing 8 parts of a red pigment 4 (C.I. Pigment Red 264, water-soluble content: 0.2%, specific electrical conductivity: 25 μS/cm) with 2 parts of the yellow pigment 1 (C.I. Pigment Yellow 139, water-soluble content: 0.4%, specific electrical conductivity: 40 μS/cm) was used instead of 10 parts of the red pigment 1 used for preparing the red pigment coloring composition 1.

[Red Pigment Coloring Composition 5]

[0153] A red pigment coloring composition 5 was prepared as described above, except that 10 parts of a red pigment 5 (C.I. Pigment Red 48:1, water-soluble content: 1.6%, specific electrical conductivity: 170 μS/cm) was used instead of 10 parts of the red pigment 1 used for preparing the red pigment coloring composition 1.

[Green Pigment Coloring Composition 1]

[0154] A green pigment coloring composition 1 was prepared as described above, except that a pigment (water-soluble content: 0.4%, specific electrical conductivity: 50 μS/cm) prepared by mixing 6 parts of a green pigment 1 (C.I. Pigment Green 36, water-soluble content: 0.3%, specific electrical conductivity: 40 μS/cm) with 4 parts of a yellow pigment 2 (C.I. Pigment Yellow 150, water-soluble content: 0.6%, specific electrical conductivity: 70 μS/cm) was used instead of 10 parts of the red pigment 1 used for preparing the red pigment coloring composition 1.

[Green Pigment Coloring Composition 2]

[0155] A green pigment coloring composition 2 was prepared as described above, except that a pigment (water-soluble content: 0.2%, specific electrical conductivity: 30 μS/cm) prepared by mixing 4 parts of a green pigment 2 (C.I. Pigment Green 7, water-soluble content: 0.2%, specific electrical conductivity: 30 μS/cm) with 6 parts of a yellow pigment 3 (C.I. Pigment Yellow 138, water-soluble content: 0.2%, specific electrical conductivity: 30 μS/cm) was used instead of 6 parts of the green pigment 1 and 4 parts of the yellow pigment 2 used for preparing the green pigment coloring composition 1.

[Green Pigment Coloring Composition 3]

[0156] A green pigment coloring composition 3 was prepared as described above, except that a pigment (water-soluble content: 0.2%, specific electrical conductivity: 30 μS/cm) prepared by mixing 6 parts of a green pigment 3 (C.I. Pigment Green 58, water-soluble content: 0.2%, specific electrical conductivity: 25 μS/cm) with 4 parts of the yellow pigment 3 (C.I. Pigment Yellow 138, water-soluble content: 0.2%, specific electrical conductivity: 30 μS/cm) was used instead of 6 parts of the green pigment 1 and 4 parts of the yellow pigment 2 used for preparing the green pigment coloring composition 1.

[Green Pigment Coloring Composition 4]

[0157] A green pigment coloring composition 4 was prepared as described above, except that a pigment (water-soluble content: 0.7%, specific electrical conductivity: 80 μS/cm) prepared by mixing 6 parts of the green pigment 3 (C.I. Pigment Green 58, water-soluble content: 0.2%, specific electrical conductivity: 25 μS/cm) with 3.6 parts of the yellow pigment 3 (C.I. Pigment Yellow 138, water-soluble content: 0.2%, specific electrical conductivity: 30 μS/cm) and 0.4 parts of the sulfonic acid derivative of YELLOW 138 which is described in Production Example 2 of Japanese Unexamined Patent Application Publication No. 2004-292785 was used instead of 6 parts of the green pigment 1 and 4 parts of the yellow pigment 2 used for preparing the green pigment coloring composition 1.

[Green Pigment Coloring Composition 5]

[0158] A green pigment coloring composition 5 was prepared as described above, except that a pigment (water-soluble content: 1.8%, specific electrical conductivity: 190 μS/cm) prepared by mixing 6 parts of a green pigment 4 (C.I. Pigment Green 4, water-soluble content: 1.7%, specific electrical conductivity: 180 μS/cm) with 4 parts of a yellow pigment 4 (C.I. Pigment Yellow 62, water-soluble content: 1.9%, specific electrical conductivity: 190 μS/cm) was used instead of 6 parts of the green pigment 1 and 4 parts of the yellow pigment 2 used for preparing the green pigment coloring composition 1.

[Blue Pigment Coloring Composition 1]

[0159] A blue pigment coloring composition 1 was prepared as described above, except that a pigment (water-soluble content: 0.3%, specific electrical conductivity: 30 prepared by mixing 9 parts of a blue pigment 1 (C.I. Pigment Blue 15:6, water-soluble content: 0.2%, specific electrical conductivity: 20 with 1 part of a purple pigment 1 (C.I. Pigment Violet 23, water-soluble content: 0.7%, specific electrical conductivity: 80 μS/cm) was used instead of 10 parts of the red pigment 1 used for preparing the red pigment coloring composition 1.

[Blue Pigment Coloring Composition 2]

[0160] A blue pigment coloring composition 2 was prepared as described above, except that a pigment (water-soluble content: 0.5%, specific electrical conductivity: 50 μS/cm) prepared using the blue pigment 1 whose water-soluble content was changed to 0.5% and whose specific electrical conductivity was changed to 50 μS/cm, that is, namely, a blue pigment 2, was used.

[Blue Pigment Coloring Composition 3]

[0161] A blue pigment coloring composition 3 was prepared as described above, except that 10 parts of a triarylmethane pigment represented by General Formula (1) (Compound No. 5 in Table 1, water-soluble content: 1.1%, specific electrical conductivity: 114 μS/cm) was used instead of 9 parts of the blue pigment 1 and 1 part of the purple pigment 1 used for preparing the blue pigment coloring composition 1.

[Blue Pigment Coloring Composition 4]

[0162] A blue pigment coloring composition 4 was prepared as described above, except that 10 parts of a blue pigment 3 (C.I. Pigment Blue 1, water-soluble content: 1.3%, specific electrical conductivity: 160 μS/cm) was used instead of 9 parts of the blue pigment 1 and 1 part of the purple pigment 1 used for preparing the blue pigment coloring composition 1.

[Blue Pigment Coloring Composition 5]

[0163] A blue pigment coloring composition 5 was prepared as described above, except that 10 parts of a blue pigment 4 (C.I. Pigment Blue 61, water-soluble content: 1.8%, specific electrical conductivity: 200 μS/cm) was used instead of 9 parts of the blue pigment 1 and 1 part of the purple pigment 1 used for preparing the blue pigment coloring composition 1.

[Yellow Pigment Coloring Composition 1]

[0164] A yellow pigment coloring composition 1 was prepared as described above, except that a pigment (water-soluble content: 1.6%, specific electrical conductivity: 120 μS/cm) prepared by mixing 9 parts of a yellow pigment 5 (C.I. Pigment Yellow 138, water-soluble content: 0.5%, specific electrical conductivity: 50 μS/cm) with 1 part of the sulfonic acid derivative of YELLOW 138 which is described in Production Example 2 of Japanese Unexamined Patent Application Publication No. 2004-292785 was used instead of 10 parts of the red pigment 1 used for preparing the red pigment coloring composition 1.

[Yellow Pigment Coloring Composition 2]

[0165] A yellow pigment coloring composition 2 was prepared as described above, except that 10 parts of the yellow pigment 2 (C.I. Pigment Yellow 150, water-soluble content: 0.6%, specific electrical conductivity: 70 μS/cm) was used instead of the yellow pigment 2 used for preparing the yellow pigment composition 1.

[Preparation of Color Filter]

[0166] A specific one of the red coloring compositions was applied to a glass substrate, on which a black matrix was deposited, by spin coating so as to form a coating film having a thickness of 2 μm. After being dried at 70°C for 20 minutes, the coating film was exposed to ultraviolet rays through a photomask using an exposure machine including an extra-high pressure mercury lamp to form a striped pattern. The patterned coating film was subjected to spray development using an alkali developing solution for 90 seconds, then washed with ion-exchanged water, and air-dried. Subsequently, post-baking was performed in a clean oven at 230°C for 30 minutes. Thus, red pixels constituted by a colored layer having a striped pattern were formed on the transparent substrate.

[0167] In the same manner, a specific one of the green coloring compositions was applied to the glass substrate by spin coating so as to form a coating film having a thickness of 2 μm. After being dried, the coating film was exposed to light using the exposure machine so that a colored layer having a striped pattern was developed at a position displaced from that of the red pixels. Thus, green pixels adjacent to the red pixels were formed.

[0168] In the same manner, a specific one of the blue coloring compositions was applied to the glass substrate by spin coating so as to form a coating film having a thickness of 2μ m. Thus, blue pixels adjacent to the red pixels and the green pixels were formed. In the above-described manner, a color filter including three-colored pixels of red, green, and blue having a striped pattern formed on the transparent substrate was prepared.

[0169] Optionally, in the same manner, a specific one of the yellow coloring compositions was also applied to the glass substrate by spin coating so as to form a coating film having a thickness of 2 μm. Thus, blue pixels adjacent to the red pixels and the green pixels were formed. As a result, a color filter including four-colored pixels of red, green, blue, and yellow having a striped pattern formed on the transparent substrate was prepared.

[0170] Color filters 1 to 4 and a comparative color filter 1 were prepared using the dye coloring compositions and the pigment coloring compositions shown in Table 8.

[Table 8]

	Color filter 1	Color filter 2	Color filter 3	Color filter 4	Comparative color filter 1
R pixel portion	Red pigment coloring composition 1	Red pigment coloring composition 2	Red pigment coloring composition 3	Red pigment coloring composition 4	Red pigment coloring composition 5
G pixel portion	Green pigment coloring composition 1	Green pigment coloring composition 2	Green pigment coloring composition 3	Green pigment coloring composition 4	Green pigment coloring composition 5
B pixel portion	Blue pigment coloring composition 1	Blue pigment coloring composition 2	Blue pigment coloring composition 3	Blue pigment coloring composition 4	Blue pigment coloring composition 5
Y pixel portion	None	Yellow pigment coloring composition 1	None	Yellow pigment coloring composition 2	Yellow pigment coloring composition 2

(Examples 1 to 4)

[0171] An electrode structure was formed on the first and second substrates, and an alignment film having a vertical alignment was formed on surfaces of the first and second substrates which faced each other. Subsequently, a rubbing treatment was performed to form a TN cell. The liquid crystal composition 1 shown in Table 9, which had a positive dielectric anisotropy, was held between the first and second substrates. Then, liquid crystal display apparatuses of Example 1 d_{gap} = 3.5 μm, alignment film: AL-1051) were each prepared using a specific one of the color filters 1 to 4 shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 10 summarizes the results.

[Table 9]

	Liquid crystal composition 1
5-Cy-Ph-F	5
7-Cy-Ph-F	6
2-Cy-Cy-Ph-OCFFF	11
3-Cy-Cy-Ph3-F	12
3-Cy-Cy-Ph-OCFFF	12
3-Cy-Ph-Ph1-OCFFF	12
4-Cy-Cy-Ph-OCFFF	10
5-Cy-Cy-Ph3-F	9
5-Cy-Cy-Ph-OCFFF	12
5-Cy-Ph-Ph3-F	11
Total composition proportion	100
Tni/°C	91.8
Δn (20°C)	0.093
Δε(20°C)	11.3

[Table 10]

	Example 1	Example 2	Example 3	Example 4
Liquid crystal composition	Liquid crystal composition 1	Liquid crystal composition 1	Liquid crystal composition 1	Liquid crystal composition 1
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.5	99.1	99.1
ID	17	25	58	80
Burn-in	Excellent	Excellent	Good	Good

[0172] The liquid crystal display apparatuses of Examples 1 to 4 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Comparative Examples 1 to 8)

[0173] The comparative liquid crystal composition 1 or 2 shown in Table 11, which had a positive dielectric anisotropy, was held inside the TN cell used in Example 1. Then, liquid crystal display apparatuses of Comparative Examples 1 to 8 were each prepared using a specific one of the color filters 1 to 4 shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 12 and 13 summarize the results.

[Table 11]

	Comparative liquid crystal composition 1	Comparative liquid crystal composition 2
5-Cy-Ph-F	5	5
7-Cy-Ph-F	6	6
2-Cy-Cy-Ph-OCFFF	11	11
3-Cy-Cy-Ph3-F	12	
3-Cy-Cy-Ph1-OCFFF		12
3-Cy-Cy-Ph-OCFFF	12	12
3-Cy-Ph-Ph1-OCFFF	12	
4-Cy-Cy-Ph-OCFFF	10	10
5-Cy-Cy-Ph3-F		9
5-Cy-Cy-Ph-OCFFF	12	12
5-Cy-Ph-Ph3-F	10	
3-Ph-VO-Ph1-CN		11
3-Cy-Cy-Ph3-CN		8
3-Cy-Ma-Ph3-CN	10	4
Total composition proportion	100	100
Tni/°C	91.1	92.1
Δn (20°C)	0.097	0.094
$\Delta\varepsilon$(20°C)	12.5	11.7

[Table 12]

	Comparative example 1	Comparative example 2	Comparative example 3	Comparative example 4
Liquid crystal composition	Comparative liquid crystal composition 1	Comparative liquid crystal composition 1	Comparative liquid crystal composition 1	Comparative liquid crystal composition 1
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	98.5	98.4	98.2	98.0
ID	120	128	144	160
Burn-in	Poor	Failure	Failure	Failure

[Table 13]

	Comparative example 5	Comparative example 6	Comparative example 7	Comparative example 8
Liquid crystal composition	Comparative liquid crystal composition 2	Comparative liquid crystal composition 2	Comparative liquid crystal composition 2	Comparative liquid crystal composition 2
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	98.4	98.4	98.1	97.8
ID	125	131	150	168
Burn-in	Failure	Failure	Failure	Failure

[0174] The liquid crystal display apparatuses of Comparative Examples 1 to 8 had a lower VHR and a higher ID than the liquid crystal display apparatuses according to the present invention. Furthermore, occurrence of a residual image was observed in the burn-in evaluation, which was not at an acceptable level.

(Comparative Example 9)

[0175] The liquid crystal composition 1 shown in Table 9, which had a positive dielectric anisotropy, was held inside the TN cell used in Example 1. Then, a liquid crystal display apparatus of Comparative Example 9 was prepared using the comparative color filter 1 shown in Table 8. The VHR and ID of the liquid crystal display apparatus were measured. The liquid crystal display apparatus was evaluated in terms of burn-in. Table 14 summarizes the results.

[Table 14]

	Comparative example 9
Liquid crystal composition	Liquid crystal composition 1
Color filter	Comparative color filter 1
VHR	97.2
ID	215
Burn-in	Failure

[0176] The liquid crystal display apparatus of Comparative Example 9 had a lower VHR and a higher ID than the liquid crystal display apparatuses according to the present invention. Furthermore, occurrence of a residual image was observed in the burn-in evaluation, which was not at an acceptable level.

(Examples 5 to 16)

[0177] A specific one of the liquid crystals shown in Table 15, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 5 to 12 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 16 to 18 summarize the results.

[Table 15]

	Liquid crystal composition 2	Liquid crystal composition 3	Liquid crystal composition 4
5-Cy-Ph-F	5	5	6
7-Cy-Ph-F	6	6	6
2-Cy-Cy-Ph-OCFFF	11	11	11
3-Cy-Cy-Ph1-F	12		
3-Cy-Cy-Ph1-OCFFF			9
3-Cy-Cy-Ph3-OCFFF		12	
3-Cy-Cy-Ph-OCFFF	12	12	12
3-Cy-Ph-Ph1-F			14
3-Cy-Ph-Ph1-OCFFF	12	12	
4-Cy-Cy-Ph-OCFFF	10	10	10
5-Cy-Cy-Ph1-F	9		
5-Cy-Cy-Ph1-OCFFF			10
5-Cy-Cy-Ph3-OCFFF		9	
5-Cy-Cy-Ph-OCFFF	12	12	10
5-Cy-Ph-Ph1-F			12
5-Cy-Ph-Ph1-OCFFF	11	11	
Total composition proportion	100	100	100
Tni/°C	96.1	98.9	97.6
Δn (20°C)	0.091	0.096	0.096
$\Delta\varepsilon$ (20°C)	10.4	10.5	8.6

[Table 16]

	Example 5	Example 6	Example 7	Example 8
Liquid crystal composition	Liquid crystal composition 2	Liquid crystal composition 2	Liquid crystal composition 2	Liquid crystal composition 2
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.5	99.3	99.2	99.1
ID	18	32	57	75
Burn-in	Excellent	Excellent	Good	Good

[Table 17]

	Example 9	Example 10	Example 11	Example 12
Liquid crystal composition	Liquid crystal composition 3	Liquid crystal composition 3	Liquid crystal composition 3	Liquid crystal composition 3
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.5	99.2	99.1
ID	15	26	52	71
Burn-in	Excellent	Excellent	Good	Good

[Table 18]

	Example 13	Example 14	Example 15	Example 16
Liquid crystal composition	Liquid crystal composition 3	Liquid crystal composition 3	Liquid crystal composition 3	Liquid crystal composition 3
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.4	99.3	99.1
ID	18	28	39	75
Burn-in	Excellent	Excellent	Excellent	Good

[0178] The liquid crystal display apparatuses of Examples 5 to 16 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 17 to 28)

[0179] A specific one of the liquid crystals shown in Table 19, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 17 to 28 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 20 to 22 summarize the results.

[Table 19]

	Liquid crystal composition 5	Liquid crystal composition 6	Liquid crystal composition 7
5-Cy-Ph-F	5	5	5
7-Cy-Ph-F	6	6	6
2-Cy-Cy-Ph1-F		12	12
3-Cy-Cy-Ph1-F	12	10	10
3-Cy-Cy-Ph1-OCFFF	12	12	12
3-Cy-Cy-Ph-OCFFF	12		
3-Cy-Ph-Ph1-OCFFF	12	12	12
4-Cy-Cy-Ph1-F		12	12
5-Cy-Cy-Ph1-F	11	11	11

(continued)

	Liquid crystal composition 5	Liquid crystal composition 6	Liquid crystal composition 7
5-Cy-Cy-Ph1-OCFFF	9	9	9
5-Cy-Cy-Ph-OCFFF	10		
5-Cy-Ph-Ph1-OCFFF	11	11	11
Total composition proportion	100	100	100
Tni/°C	91.1	83.5	86.8
Δn (20°C)	0.092	0.089	0.092
$\Delta\varepsilon$ (20°C)	9.9	8.3	7.9

[Table 20]

	Example 17	Example 18	Example 19	Example 20
Liquid crystal composition	Liquid crystal composition 5	Liquid crystal composition 5	Liquid crystal composition 5	Liquid crystal composition 5
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.3	99.1
ID	15	21	49	72
Burn-in	Excellent	Excellent	Good	Good

[Table 21]

	Example 21	Example 22	Example 23	Example 24
Liquid crystal composition	Liquid crystal composition 6	Liquid crystal composition 6	Liquid crystal composition 6	Liquid crystal composition 6
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.4	99.2	99.0
ID	12	31	50	73
Burn-in	Excellent	Excellent	Good	Good

[Table 22]

	Example 25	Example 26	Example 27	Example 28
Liquid crystal composition	Liquid crystal composition 7	Liquid crystal composition 7	Liquid crystal composition 7	Liquid crystal composition 7
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.5	99.2	99.1
ID	17	22	59	74
Burn-in	Excellent	Excellent	Good	Good

[0180] The liquid crystal display apparatuses of Examples 17 to 28 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 29 to 40)

[0181] A specific one of the liquid crystals shown in Table 23, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 29 to 40 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 24 to 26 summarize the results.

[Table 23]

	Liquid crystal composition 8	Liquid crystal composition 9	Liquid crystal composition 10
5-Cy-2-Ph1-F		5	
5-Cy-Ph-F		10	
5-Ph1-Ph-OCFFF	8		
7-Cy-2-Ph1-F		5	
7-Cy-Ph3-F			8
7-Cy-Ph-F		15	
7-Ph1-Ph-OCFFF	7		
2-Cy-Cy-Ph-OCFFF	13	9	
3-Cy-2-Cy-Ph3-F			10
3-Cy-Cy-2-Ph3-F			10
3-Cy-Cy-Ph3-F	12		6
3-Cy-Cy-Ph-OCFFF	15	12	
3-Cy-Ph1-Ph-OCFF		7	
3-Cy-Ph-CFFO-Ph3-F			5
3-Cy-Ph-CFFO-Ph-OCFFF			5
3-Cy-Ph-Ph1-F		13	
3-Cy-Ph-Ph1-OCFF		8	
3-Cy-Ph-Ph3-F	9		5
4-Cy-2-Cy-Ph3-F			6
4-Cy-Cy-Ph3-F			3
4-Cy-Cy-Ph-OCFFF	13		
5-Cy-2-Cy-Ph3-F			6
5-Cy-Cy-2-Ph3-F			5
5-Cy-Cy-Ph3-F	9		
5-Cy-Cy-Ph-OCFFF	14	12	
5-Cy-Ph-CFFO-Ph1-F			5
5-Cy-Ph-CFFO-Ph3-F			10
5-Cy-Ph-CFFO-Ph-CF3			5

(continued)

	Liquid crystal composition 8	Liquid crystal composition 9	Liquid crystal composition 10
5-Cy-Ph-Ph3-F			5
3-Cy-Cy-2-Ph-Ph3-F			3
3-Cy-Cy-Ph1-Ph-F		4	
3-Cy-Cy-Ph-Ph3-F			3
Total composition proportion	100	100	100
Tni/°C	79.8	65.1	61.7
Δn (20°C)	0.0876	0.0995	0.0827
Δε (20°C)	8.7	7.6	7.3

[Table 24]

	Example 29	Example 30	Example 31	Example 32
Liquid crystal composition	Liquid crystal composition 8	Liquid crystal composition 8	Liquid crystal composition 8	Liquid crystal composition 8
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.5	99.2	99.0
ID	13	19	55	74
Burn-in	Excellent	Excellent	Excellent	Good

[Table 25]

	Example 33	Example 34	Example 35	Example 36
Liquid crystal composition	Liquid crystal composition 9	Liquid crystal composition 9	Liquid crystal composition 9	Liquid crystal composition 9
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.5	99.5	99.3	99.2
ID	20	22	37	52
Burn-in	Excellent	Excellent	Excellent	Good

[Table 26]

	Example 37	Example 38	Example 39	Example 40
Liquid crystal composition	Liquid crystal composition 10	Liquid crystal composition 10	Liquid crystal composition 10	Liquid crystal composition 10
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.4	99.3	99.2
ID	18	29	42	56
Burn-in	Excellent	Excellent	Good	Good

[0182] The liquid crystal display apparatuses of Examples 29 to 40 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 41 to 56)

[0183] A specific one of the liquid crystals shown in Tables 27 and 28, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 41 to 56 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 29 to 32 summarize the results.

[Table 27]

	Liquid crystal composition 11	Liquid crystal composition 12	Liquid crystal composition 13
3-Cy-2-Ph1-Cl	5		
3-Cy-Ph1-Cl			11
5-Cy-2-Ph1-Cl	5		
5-Cy-Ph1-Cl			10
2-Cy-Cy-Ph3-Cl		10	
3-Cy-Cy-Ph3-Cl		9	
5-Cy-Cy-Ph3-Cl		11	
5-Cy-Ph-F	11	7	
6-Cy-Ph-F		4	
7-Cy-Ph-F	13	6	10
2-Cy-Cy-Ph-OCFFF	9	9	9
3-Cy-Cy-Ph-OCFFF	12	11	12
3-Cy-Ph1-Ph-CFFF	5		5
3-Cy-Ph1-Ph-F			10
3-Cy-Ph1-Ph-OCFFF		12	
4-Cy-Cy-Ph-OCFFF	7		7
5-Cy-Cy-Ph-OCFFF	12	12	12
5-Cy-Ph1-Ph-CFFF	5		
5-Cy-Ph1-Ph-OCFFF		9	
5-Cy-Ph-Ph1-F	13		8
2-Cy-Cy-Ph1-Ph-F	3		
3-Cy-Cy-Ph1-Ph-F			3
5-Cy-Cy-Ph1-Ph-F			3
Total composition proportion	100	100	100
Tni/°C	65.8	86.2	70.7
Δn (20°C)	0.0825	0.0923	0.0992
$\Delta\varepsilon$ (20°C)	7.5	6.2	6.9

[Table 28]

	Liquid crystal composition 14
3-Cy-Cy-Ph-Cl	4
5-Cy-Cy-Ph-Cl	4
2-Cy-Ph-Ph1-F	3
2-Cy-Ph-Ph-F	3
3-Cy-2-Cy-Ph3-F	6
3-Cy-Cy-2-Ph3-F	12
3-Cy-Cy-Ph3-F	3
3-Cy-Ph-CFFO-Ph-OCFFF	5
3-Cy-Ph-Ph1-F	3
3-Cy-Ph-Ph3-F	6
3-Cy-Ph-Ph-F	3
4-Cy-2-Cy-Ph3-F	6
4-Cy-Cy-Ph3-F	3
5-Cy-2-Cy-Ph3-F	6
5-Cy-Cy-2-Ph3-F	6
5-Cy-Ph-CFFO-Ph3-F	10
5-Cy-Ph-CFFO-Ph-CF3	5
5-Cy-Ph-Ph1-F	6
5-Cy-Ph-Ph3-F	6
Total composition proportion	100
Tni/°C	82.4
Δn (20°C)	0.0998
$\Delta\varepsilon$ (20°C)	10.9

[Table 29]

	Example 41	Example 42	Example 43	Example 44
Liquid crystal composition	Liquid crystal composition 11	Liquid crystal composition 11	Liquid crystal composition 11	Liquid crystal composition 11
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.4	99.3
ID	12	18	33	45
Burn-in	Excellent	Excellent	Excellent	Excellent

[Table 30]

	Example 45	Example 46	Example 47	Example 48
Liquid crystal composition	Liquid crystal composition 12	Liquid crystal composition 12	Liquid crystal composition 12	Liquid crystal composition 12
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.7	99.5	99.3
ID	11	13	34	51
Burn-in	Excellent	Excellent	Excellent	Good

[Table 31]

	Example 49	Example 50	Example 51	Example 52
Liquid crystal composition	Liquid crystal composition 13	Liquid crystal composition 13	Liquid crystal composition 13	Liquid crystal composition 13
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.5	99.3	99.2
ID	13	16	36	54
Burn-in	Excellent	Excellent	Good	Excellent

[Table 32]

	Example 53	Example 54	Example 55	Example 56
Liquid crystal composition	Liquid crystal composition 14	Liquid crystal composition 14	Liquid crystal composition 14	Liquid crystal composition 14
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.8	99.6	99.4	99.4
ID	10	18	39	37
Burn-in	Excellent	Excellent	Good	Good

[0184] The liquid crystal display apparatuses of Examples 41 to 56 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 57 to 72)

[0185] A specific one of the liquid crystals shown in Table 33, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 57 to 72 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 34 to 37 summarize the results.

[Table 33]

	Liquid crystal composition 15	Liquid crystal composition 16	Liquid crystal composition 17	Liquid crystal composition 18
3-Cy-Ph-Cl				4
5-Cy-Ph-Cl				4

(continued)

	Liquid crystal composition 15	Liquid crystal composition 16	Liquid crystal composition 17	Liquid crystal composition 18
7-Cy-Ph-Cl				5
2-Cy-Cy-Ph-Cl				6
3-Cy-2-Cy-Ph1-Cl				3
3-Cy-Cy-Ph-Cl				7
5-Cy-Cy-Ph-Cl				6
3-Cy-Ph-OCFFF	4	4		
3-Ph-Ph-OCFFF			8	
4-Cy-Ph-OCFFF	6	6		
5-Cy-Ph-OCFFF	7	7		
5-Ph-Ph-OCFFF			13	
7-Ph-Ph-OCFFF			13	
2-Cy-Cy-Ph-OCFFF			8	
2-Cy-Ph-Ph1-F	8	8		6
3-Cy-Cy-Ph-OCFFF			13	
3-Cy-Ph1-Ph-CFFF		9		
3-Cy-Ph1-Ph-F	12	12		
3-Cy-Ph1-Ph-OCFFF	9			
3-Cy-Ph-CFFO-Ph3-F				5
3-Cy-Ph-CFFO-Ph-OCFFF				5
3-Cy-Ph-Ph1-F			14	6
3-Cy-Ph-Ph3-F	12	12		13
4-Cy-Cy-Ph-OCFFF			5	
4-Cy-Ph-Ph3-F	10	10		
5-Cy-Cy-Ph-OCFFF			12	
5-Cy-Ph1-Ph-CFFF		11		
5-Cy-Ph1-Ph-OCFFF	11			
5-Cy-Ph-Ph1-F	10	10	14	12
5-Cy-Ph-Ph3-F	11	11		13
3-Cy-Ph1-T-Ph-2				3
3-Cy-Ph1-V-Ph-2				2
Total composition proportion	100	100	100	100
Tni/°C	65.9	61.7	65.6	89.1
Δn (20°C)	0.1116	0.1155	0.117	0.1274
$\Delta\varepsilon$ (20°C)	5.9	7.3	10.5	6.2

[Table 34]

	Example 57	Example 58	Example 59	Example 60
Liquid crystal composition	Liquid crystal composition 15	Liquid crystal composition 15	Liquid crystal composition 15	Liquid crystal composition 15
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.7	99.3	99.2
ID	18	17	52	62
Burn-in	Excellent	Excellent	Good	Good

[Table 35]

	Example 61	Example 62	Example 63	Example 64
Liquid crystal composition	Liquid crystal composition 16	Liquid crystal composition 16	Liquid crystal composition 16	Liquid crystal composition 16
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.5	99.5	99.2	99.1
ID	15	19	63	71
Burn-in	Excellent	Excellent	Good	Good

[Table 36]

	Example 65	Example 66	Example 67	Example 68
Liquid crystal composition	Liquid crystal composition 17	Liquid crystal composition 17	Liquid crystal composition 17	Liquid crystal composition 17
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.4	99.2	99.1
ID	16	34	58	75
Burn-in	Excellent	Excellent	Good	Good

[Table 37]

	Example 69	Example 70	Example 71	Example 72
Liquid crystal composition	Liquid crystal composition 18	Liquid crystal composition 18	Liquid crystal composition 18	Liquid crystal composition 18
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.5	99.5	99.3	99.1
ID	20	19	43	67
Burn-in	Excellent	Excellent	Excellent	Good

[0186] The liquid crystal display apparatuses of Examples 57 to 72 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 73 to 80)

[0187] A specific one of the liquid crystals shown in Table 38, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 73 to 80 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 39 and 40 summarize the results.

[Table 38]

	Liquid crystal composition 19	Liquid crystal composition 20
5-Cy-Ph-F	6	5
7-Cy-Ph-F	6	6
2-Cy-Ph-Ph1-F	8	
3-Cy-2-Cy-Ph-OCFFF	8	
3-Cy-Cy-2-Ph-OCFFF	8	
3-Cy-Cy-Ph1-OCFFF		12
3-Cy-Cy-Ph-OCFFF		12
3-Cy-Ph-CFFO-Ph3-F	3	
3-Cy-Ph-CFFO-Ph-OCFFF	5	
3-Cy-Ph-Ph1-F	8	12
3-Cy-Ph-Ph1-OCFFF		12
5-Cy-2-Cy-Ph-OCFFF	8	
5-Cy-Cy-2-Ph-OCFFF	8	
5-Cy-Cy-Ph1-OCFFF		9
5-Cy-Cy-Ph-OCFFF	8	10
5-Cy-Ph-CFFO-Ph3-F	8	
5-Cy-Ph-Ph1-F	16	11
5-Cy-Ph-Ph1-OCFFF		11
Total composition proportion	100	100
Tni/°C	84.5	89.3
Δn (20°C)	0.1004	0.105
$\Delta\varepsilon$ (20°C)	6.3	9.7

[Table 39]

	Example 73	Example 74	Example 75	Example 76
Liquid crystal composition	Liquid crystal composition 19	Liquid crystal composition 19	Liquid crystal composition 19	Liquid crystal composition 19
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.4	99.3	99.2
ID	14	37	51	72
Burn-in	Excellent	Excellent	Good	Good

[Table 40]

	Example 77	Example 78	Example 79	Example 80
Liquid crystal composition	Liquid crystal composition 20	Liquid crystal composition 20	Liquid crystal composition 20	Liquid crystal composition 20
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.5	99.4	99.3
ID	14	23	41	52
Burn-in	Excellent	Excellent	Excellent	Good

[0188] The liquid crystal display apparatuses of Examples 73 to 80 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 81 to 88)

[0189] A specific one of the liquid crystals shown in Table 41, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 81 to 88 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 42 and 43 summarize the results.

[Table 41]

	Liquid crystal composition 21	Liquid crystal composition 22
3-Ph1-Ph-Cl		6
5-Ph1-Ph-Cl		7
2-Cy-Ph-Ph3-Cl	5	5
3-Cy-Ph-Ph3-Cl	9	9
5-Cy-Ph-Ph3-Cl	11	11
3-Ph-Ph1-F	6	
5-Ph-Ph1-F	7	
2-Cy-Ph-Ph1-F	8	8
3-Cy-2-Ph-Ph1-F	11	11
3-Cy-Ph-Ph1-F	12	12
4-Cy-2-Ph-Ph1-F	10	10
5-Cy-2-Ph-Ph1-F	11	11
5-Cy-Ph-Ph1-F	10	10
Total composition proportion	100	100
Tni/°C	85.3	83.1
Δn (20°C)	0.1474	0.1582
$\Delta\varepsilon$ (20°C)	5.9	5.4

[Table 42]

	Example 81	Example 82	Example 83	Example 84
Liquid crystal composition	Liquid crystal composition 21	Liquid crystal composition 21	Liquid crystal composition 21	Liquid crystal composition 21
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.4	99.3
ID	13	19	39	53
Burn-in	Excellent	Excellent	Excellent	Good

[Table 43]

	Example 85	Example 86	Example 87	Example 88
Liquid crystal composition	Liquid crystal composition 22	Liquid crystal composition 22	Liquid crystal composition 22	Liquid crystal composition 22
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.4	99.2	99.1
ID	25	37	67	78
Burn-in	Excellent	Excellent	Good	Good

[0190] The liquid crystal display apparatuses of Examples 81 to 88 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 89 to 96)

[0191] A specific one of the liquid crystals shown in Table 44, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 89 to 96 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 45 and 46 summarize the results.

[Table 44]

	Liquid crystal composition 23	Liquid crystal composition 24
5-Cy-Cy-1	6	5
0d1-Cy-Cy-3	24	35
1d1-Cy-Cy-3	5	9
0d1-Cy-Cy-Ph-1		2
0d1-Cy-Ph-Ph-3	5	9
5-Cy-Ph-F	3	2
7-Cy-Ph-F	4	2
2-Cy-Cy-Ph-OCFFF	7	4
3-Cy-Cy-Ph-OCFFF	7	5
4-Cy-Cy-Ph-OCFFF	6	4
5-Cy-Cy-Ph-OCFFF	7	5
3-Cy-Cy-Ph3-F	7	5

(continued)

	Liquid crystal composition 23	Liquid crystal composition 24
5-Cy-Cy-Ph3-F	5	4
3-Cy-Ph-Ph1-OCFFF	7	5
5-Cy-Ph-Ph3-F	7	4
Total composition proportion	100	100
Tni/°C	75.7	75.0
Δn (20°C)	0.087	0.084
$\Delta\varepsilon$ (20°C)	4.7	3.0

[Table 45]

	Example 89	Example 90	Example 91	Example 92
Liquid crystal composition	Liquid crystal composition 23	Liquid crystal composition 23	Liquid crystal composition 23	Liquid crystal composition 23
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.4	99.3
ID	14	22	41	52
Burn-in	Excellent	Excellent	Excellent	Excellent

[Table 46]

	Example 93	Example 94	Example 95	Example 96
Liquid crystal composition	Liquid crystal composition 24	Liquid crystal composition 24	Liquid crystal composition 24	Liquid crystal composition 24
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.7	99.3	99.2
ID	16	14	50	66
Burn-in	Excellent	Excellent	Good	Good

[0192] The liquid crystal display apparatuses of Examples 89 to 96 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 97 to 104)

[0193] A specific one of the liquid crystals shown in Table 47, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 97 to 104 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 48 and 49 summarize the results.

[Table 47]

	Liquid crystal composition 25	Liquid crystal composition 26
5-Cy-Cy-1	5	
0d1-Cy-Cy-3	12	31

(continued)

	Liquid crystal composition 25	Liquid crystal composition 26
1d1-Cy-Cy-3	12	11
0d1-Cy-Cy-Ph-1	9	9
0d3-Cy-Cy-Ph-1	5	
0d1-Cy-Ph-Ph-3	5	9
7-Cy-Ph-F	5	3
3-Cy-Cy-Ph3-F	4	3
4-Cy-Cy-Ph3-F	2	
3-Cy-2-Cy-Ph3-F	6	4
4-Cy-2-Cy-Ph3-F	3	2
5-Cy-2-Cy-Ph3-F	3	2
3-Cy-Cy-2-Ph3-F	6	4
5-Cy-Cy-2-Ph3-F	3	2
3-Cy-Ph-Ph3-F	3	2
5-Cy-Ph-Ph3-F	3	2
5-Ph-Ph3-CFFO-Ph-CF3	3	2
5-Ph-Ph3-CFFO-Ph1-F	3	2
3-Ph-Ph3-CFFO-Ph3-F	3	2
5-Ph-Ph3-CFFO-Ph3-F	6	4
3-Ph-Ph3-CFFO-Ph-OCFFF	3	2
3-Cy-Cy-Ph-Ph3-F	2	2
3-Cy-Cy-2-Ph-Ph3-F	2	2
Total composition proportion	108	100
Tni/°C	75.2	75.3
Δn (20°C)	0.087	0.081
$\Delta\varepsilon$ (20°C)	4.7	3.0

[Table 48]

	Example 97	Example 98	Example 99	Example 100
Liquid crystal composition	Liquid crystal composition 25	Liquid crystal composition 25	Liquid crystal composition 25	Liquid crystal composition 25
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.5	99.3	99.2
ID	14	34	62	71
Burn-in	Excellent	Excellent	Excellent	Good

[Table 49]

	Example 101	Example 102	Example 103	Example 104
Liquid crystal composition	Liquid crystal composition 26	Liquid crystal composition 26	Liquid crystal composition 26	Liquid crystal composition 26
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.8	99.6	99.4	99.4
ID	15	19	37	34
Burn-in	Excellent	Excellent	Excellent	Excellent

[0194] The liquid crystal display apparatuses of Examples 97 to 104 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 105 to 112)

[0195] A specific one of the liquid crystals shown in Table 50, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 105 to 112 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 51 and 52 summarize the results.

[Table 50]

	Liquid crystal composition 27	Liquid crystal composition 28
5-Cy-Cy-1	5	5
0d1-Cy-Cy-3	21	31
1d1-Cy-Cy-3	5	10
0d1-Cy-Cy-Ph-1		5
0d9-Cy-Ph-Ph-3	9	9
2-Cy-Cy-Ph-F	2	2
3-Cy-Cy-Ph-Cl	2	2
5-Cy-Cy-Ph-Cl	2	2
3-Cy-Cy-Ph3-F	2	2
4-Cy-Cy-Ph3-F	2	
3-Cy-2-Cy-Ph3-F	3	2
4-Cy-2-Cy-Ph3-F	3	2
5-Cy-2-Cy-Ph3-F	3	2
3-Cy-Cy-2-Ph3-F	7	4
5-Cy-Cy-2-Ph3-F	4	2
2-Cy-Ph-Ph-F	2	2
3-Cy-Ph-Ph-F	2	2
2-Cy-Ph-Ph1-F	2	2
5-Cy-Ph-Ph1-F	4	2
3-Cy-Ph-Ph3-F	4	2
5-Cy-Ph-Ph3-F	4	2

(continued)

	Liquid crystal composition 27	Liquid crystal composition 28
5-Ph-Ph3-CFFO-Ph-CF3	3	2
5-Ph-Ph3-CFFO-Ph3-F	6	4
3-Ph-Ph3-CFFO-Ph-OCFFF	3	2
Total composition proportion	100	100
Tni/°C	75.3	75.0
Δn (20°C)	0.095	0.089
$\Delta\varepsilon$ (20°C)	4.9	3.2

[Table 51]

	Example 105	Example 106	Example 107	Example 108
Liquid crystal composition	Liquid crystal composition 27	Liquid crystal composition 27	Liquid crystal composition 27	Liquid crystal composition 27
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.6	99.5	99.3
ID	12	15	36	66
Burn-in	Excellent	Excellent	Excellent	Good

[Table 52]

	Example 109	Example 110	Example 111	Example 112
Liquid crystal composition	Liquid crystal composition 28	Liquid crystal composition 28	Liquid crystal composition 28	Liquid crystal composition 28
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.5	99.3	99.2
ID	16	27	53	72
Burn-in	Excellent	Excellent	Good	Good

[0196] The liquid crystal display apparatuses of Examples 105 to 112 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 113 to 120)

[0197] A specific one of the liquid crystals shown in Table 53, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 113 to 120 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 54 and 55 summarize the results.

[Table 53]

	Liquid crystal composition 29	Liquid crystal composition 30
0d1-Cy-Cy-3	25	33
1d1-Cy-Cy-3		4

(continued)

	Liquid crystal composition 29	Liquid crystal composition 30
0d1-Cy-Ph-Ph-3		3
3-Cy-Ph-Cl	3	2
5-Cy-Ph-Cl	3	2
7-Cy-Ph-Cl	4	3
2-Cy-Cy-Ph-Cl	4	4
3-Cy-Cy-Ph-Cl	4	4
5-Cy-Cy-Ph-Cl	4	4
3-Cy-2-Cy-Ph1-Cl	2	2
2-Cy-Ph-Ph1-F	5	4
3-Cy-Ph-Ph1-F	5	4
5-Cy-Ph-Ph1-F	9	6
3-Cy-Ph-Ph3-F	10	8
5-Cy-Ph-Ph3-F	10	8
3-Ph-Ph3-CFFO-Ph3-F	4	3
3-Ph-Ph3-CFFO-Ph-OCFFF	4	3
3-Cy-Ph1-T-Ph-2	2	2
3-Cy-Ph1-V-Ph-2	2	1
Total composition proportion	100	100
Tni/°C	77.7	75.7
Δn (20°C)	0.107	0.100
$\Delta\varepsilon$ (20°C)	3.9	3.0

[Table 54]

	Example 113	Example 114	Example 115	Example 116
Liquid crystal composition	Liquid crystal composition 29	Liquid crystal composition 29	Liquid crystal composition 29	Liquid crystal composition 29
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.4	99.3
ID	17	23	48	60
Burn-in	Excellent	Excellent	Excellent	Good

[Table 55]

	Example 117	Example 118	Example 119	Example 120
Liquid crystal composition	Liquid crystal composition 30	Liquid crystal composition 30	Liquid crystal composition 30	Liquid crystal composition 30
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.4	99.5
ID	19	22	45	35

(continued)

	Example 117	Example 118	Example 119	Example 120
Liquid crystal composition	Liquid crystal composition 30	Liquid crystal composition 30	Liquid crystal composition 30	Liquid crystal composition 30
Burn-in	Excellent	Excellent	Excellent	Excellent

[0198] The liquid crystal display apparatuses of Examples 113 to 120 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 121 to 128)

[0199] A specific one of the liquid crystals shown in Table 56, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 121 to 128 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Tables 57 and 58 summarize the results.

[Table 56]

	Liquid crystal composition 31	Liquid crystal composition 32
5-Cy-Cy-1		5
0d1-Cy-Cy-3	20	22
1d1-Cy-Cy-3	5	9
0d1-Cy-Cy-Ph-1		5
0d1-Cy-Ph-Ph-3		4
5-Cy-Ph-F	5	4
7-Cy-Ph-F	5	4
5-Cy-Cy-Ph-OCFFF	6	4
3-Cy-2-Cy-Ph-OCFFF	6	4
5-Cy-2-Cy-Ph-OCFFF	6	4
3-Cy-Cy-2-Ph-OCFFF	6	4
5-Cy-Cy-2-Ph-OCFFF	6	4
2-Cy-Ph-Ph1-F	6	4
3-Cy-Ph-Ph1-F	6	4
5-Cy-Ph-Ph1-F	12	9
3-Ph-Ph3-CFFO-Ph3-F	2	3
5-Ph-Ph3-CFFO-Ph3-F	5	4
3-Ph-Ph3-CFFO-Ph-OCFFF	4	3
Total composition proportion	100	100
Tni/°C	76.1	76.0
Δn (20°C)	0.088	0.090
$\Delta\varepsilon$ (20°C)	3.9	3.0

[Table 57]

	Example 121	Example 122	Example 123	Example 124
Liquid crystal composition	Liquid crystal composition 31	Liquid crystal composition 31	Liquid crystal composition 31	Liquid crystal composition 31
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.5	99.3	99.3
ID	22	39	59	68
Burn-in	Excellent	Excellent	Good	Good

[Table 58]

	Example 125	Example 126	Example 127	Example 128
Liquid crystal composition	Liquid crystal composition 32	Liquid crystal composition 32	Liquid crystal composition 32	Liquid crystal composition 32
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.8	99.6	99.5	99.4
ID	20	29	40	56
Burn-in	Excellent	Excellent	Good	Good

[0200] The liquid crystal display apparatuses of Examples 121 to 128 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 129 to 132)

[0201] A liquid crystal composition 33 was prepared by mixing the liquid crystal composition 1 used in Example 1, which had a positive dielectric anisotropy, with 0.3% by mass of 2-methyl-acrylic acid 4'-{2-[4-(2-acryloyloxy-ethyl)-phenoxycarbonyl]-ethyl}-biphenyl-4-yl ester. The liquid crystal composition 33 was held inside the TN cell used in Example 1. While a driving voltage was applied between the electrodes, ultraviolet irradiation (3.0 J/cm^2) was done for 600 seconds to perform a polymerization treatment. Subsequently, liquid crystal display apparatuses of Examples 129 to 132 were each prepared using a specific one of the color filters 1 to 4 shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 59 summarizes the results.

[Table 59]

	Example 129	Example 130	Example 131	Example 132
Liquid crystal composition	Liquid crystal composition 33	Liquid crystal composition 33	Liquid crystal composition 33	Liquid crystal composition 33
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.4	99.3	99.2
ID	19	39	57	73
Burn-in	Excellent	Good	Good	Good

[0202] The liquid crystal display apparatuses of Examples 129 to 132 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 133 to 136)

[0203] A liquid crystal composition 34 was prepared by mixing the liquid crystal composition 29 having a positive dielectric anisotropy with 0.3% by mass of bismethacrylic acid biphenyl-4,4'-diyl ester. The liquid crystal composition 34 was held inside the TN cell used in Example 1. While a driving voltage was applied between the electrodes, ultraviolet irradiation (3.0 J/cm^2) was done for 600 seconds to perform a polymerization treatment. Subsequently, liquid crystal display apparatuses of Examples 133 to 136 were each prepared using a specific one of the color filters 1 to 4 shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 60 summarizes the results.

[Table 60]

	Example 133	Example 134	Example 135	Example 136
Liquid crystal composition	Liquid crystal composition 34	Liquid crystal composition 34	Liquid crystal composition 34	Liquid crystal composition 34
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.4	99.3
ID	17	25	46	59
Burn-in	Excellent	Excellent	Good	Good

[0204] The liquid crystal display apparatuses of Examples 133 to 136 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 137 to 140)

[0205] A liquid crystal composition 35 was prepared by mixing the liquid crystal composition 32 having a positive dielectric anisotropy with 0.3% by mass of bismethacrylic acid 3-fluorobiphenyl-4,4'-diyl ester. The liquid crystal composition 35 was held inside the TN cell used in Example 1. While a driving voltage was applied between the electrodes, ultraviolet irradiation (3.0 J/cm^2) was done for 600 seconds to perform a polymerization treatment. Subsequently, liquid crystal display apparatuses of Examples 137 to 140 were each prepared using a specific one of the color filters 1 to 4 shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 61 summarizes the results.

[Table 61]

	Example 137	Example 138	Example 139	Example 140
Liquid crystal composition	Liquid crystal composition 35	Liquid crystal composition 35	Liquid crystal composition 35	Liquid crystal composition 35
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.8	99.6	99.3	99.4
ID	15	27	59	47
Burn-in	Excellent	Excellent	Good	Good

[0206] The liquid crystal display apparatuses of Examples 137 to 140 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 141 to 144)

[0207] The liquid crystal shown in Table 62, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 141 to 144 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were

measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 63 summarizes the results.

[Table 62]

	Liquid crystal composition 36
0d1-Cy-Cy-Ph-1	16
3-Ph-Ph3-CFFO-Ph3-F	12
3-Cy-Cy-CFFO-Ph3-F	7
3-Ph-Ph1-PH3-CFFO-Ph3-F	2
0d1-Cy-Cy-3	28
1d1-Cy-Cy-3	9
0d3-Cy-Cy-Ph-1	14
2-Ph-Ph3-CFFO-Ph3-F	2
2-Py-Ph-Ph3-CFFO-Ph3-F	3
3-Py-Ph-Ph3-CFFO-Ph3-F	6
3-Ph-Ph-Ph1-Ph3-F	1
Total composition proportion	100
Tni/°C	90.0
Δn (20°C)	0.105
$\Delta\varepsilon$ (20°C)	7.0

[Table 63]

	Example 141	Example 142	Example 143	Example 144
Liquid crystal composition	Liquid crystal composition 36	Liquid crystal composition 36	Liquid crystal composition 36	Liquid crystal composition 36
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.8	99.7	99.5	99.4
ID	15	25	42	53
Burn-in	Excellent	Excellent	Excellent	Good

[0208] The liquid crystal display apparatuses of Examples 141 to 144 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 145 to 148)

[0209] The liquid crystal shown in Table 64, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 145 to 148 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 65 summarizes the results.

[Table 64]

	Liquid crystal composition 37
0d1-Cy-Cy-3	15
1d1-Cy-Cy-3	2

(continued)

	Liquid crystal composition 37
2-Cy-Cy-Ph3-F	8
0d1-Cy-Cy-Ph-1	8
3-Cy-Cy-Ph-OCFFF	14
3-Cy-Ph-Ph3-F	9
3-Ph-Ph3-CFFO-Ph3-F	11
3-Cy-Cy-CFFO-Ph3-F	9
5-Cy-Cy-CFFO-Ph3-F	8
2-Ph-Ph1-Ph-3	6
2-Ph-Ph1-Ph-4	4
3-Cy-Cy-Ph 1-Ph3-F	3
5-Ph1-Ph3-CFFO-Ph3-F	3
Total composition proportion	100
Tni/°C	90.4
Δn (20°C)	0.105
$\Delta\varepsilon$ (20°C)	9.0

[Table 65]

	Example 145	Example 146	Example 147	Example 148
Liquid crystal composition	Liquid crystal composition 37	Liquid crystal composition 37	Liquid crystal composition 37	Liquid crystal composition 37
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.7	99.6	99.4	99.4
ID	18	22	49	51
Burn-in	Excellent	Excellent	Excellent	Excellent

[0210] The liquid crystal display apparatuses of Examples 145 to 148 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation.

(Examples 149 to 152)

[0211] The liquid crystal shown in Table 66, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 149 to 152 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 67 summarizes the results.

[Table 66]

	Liquid crystal composition 38
0d1-Cy-Cy-3	38
1d1-Cy-Cy-3	14
3-Ph-Ph3-CFFO-Ph3-F	8
3-Cy-Cy-CFFO-Ph3-F	15

(continued)

	Liquid crystal composition 38
0d3-Cy-Cy-Ph-1	9
3-Ph-Ph1-Ph3-CFFO-Ph3-F	2
4-Ph-Ph1-Ph3-CFFO-Ph3-F	7
5-Ph-Ph1-Ph3-CFFO-Ph3-F	7
Total composition proportion	100
Tni/°C	81.8
Δn (20°C)	0.099
$\Delta\varepsilon$ (20°C)	8.0

[Table 67]

	Example 149	Example 150	Example 151	Example 152
Liquid crystal composition	Liquid crystal composition 38	Liquid crystal composition 38	Liquid crystal composition 38	Liquid crystal composition 38
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.8	99.6	99.3	99.3
ID	15	25	60	66
Burn-in	Excellent	Excellent	Excellent	Good

[0212] The liquid crystal display apparatuses of Examples 149 to 152 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 153 to 156)

[0213] The liquid crystal shown in Table 68, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 153 to 156 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 69 summarizes the results.

[Table 68]

	Liquid crystal composition 39
3-Ph-Ph3-CFFO-Ph3-F	12
0d1-Cy-Cy-3	25
1d1-Cy-Cy-3	7
0d1-Cy-Cy-Ph-1	16
3-Ph-Ph1-Ph3-CFFO-Ph3-F	5
0d3-Cy-Cy-Ph-1	8
3-Py-Ph-Ph3-CFFO-Ph3-F	5
5-Cy-Cy-CFFO-Ph3-F	4
2-Py-Ph-Ph3-CFFO-Ph3-F	3
3-Cy-Ph-Ph1-F	5

(continued)

	Liquid crystal composition 39
3-Cy-Cy-CFFO-Ph3-F	10
Total composition proportion	100
Tni/°C	85.3
Δn (20°C)	0.105
Δε (20°C)	9.3

[Table 69]

	Example 153	Example 154	Example 155	Example 156
Liquid crystal composition	Liquid crystal composition 39	Liquid crystal composition 39	Liquid crystal composition 39	Liquid crystal composition 39
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.6	99.5	99.3	99.2
ID	23	38	64	68
Burn-in	Excellent	Excellent	Excellent	Good

[0214] The liquid crystal display apparatuses of Examples 153 to 156 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation. Even when a residual image was present, it was very slight and at an acceptable level.

(Examples 157 to 160)

[0215] The liquid crystal shown in Table 70, which had a positive dielectric anisotropy, was held between the first and second substrates as in Example 1. Then, liquid crystal display apparatuses of Examples 157 to 160 were each prepared using a specific one of the color filters shown in Table 8. The VHR and ID of each liquid crystal display apparatus were measured. Each liquid crystal display apparatus was evaluated in terms of burn-in. Table 71 summarizes the results.

[Table 70]

	Liquid crystal composition 40
3-Ph-Ph3-CFFO-Ph3-F	7
0d1-Cy-Cy-3	34
0d1-Cy-Cy-Ph-1	7
3-Cy-Cy-CFFO-Ph3-F	8
3-Cy-Cy-Ph1-Ph3-F	9
3-Py-Ph-Ph3-CFFO-Ph3-F	10
5-Cy-Cy-CFFO-Ph3-F	10
3-Cy-Cy-Ph-OCFFF	4
3-Ph-Ph1-Ph3-F	6
3-Cy-Ph-Ph-Cy-3	5
Total composition proportion	100
Tni/°C	93.2
Δn (20°C)	0.098

(continued)

	Liquid crystal composition 40
Δε (20°C)	9.3

[Table 71]

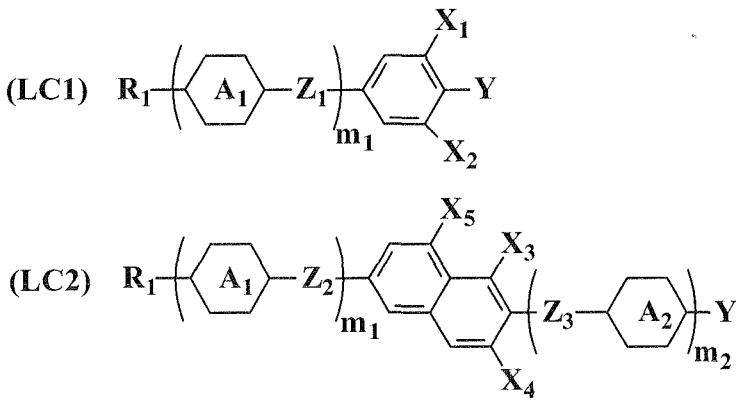
	Example 157	Example 158	Example 159	Example 160
Liquid crystal composition	Liquid crystal composition 40	Liquid crystal composition 40	Liquid crystal composition 40	Liquid crystal composition 40
Color filter	Color filter 1	Color filter 2	Color filter 3	Color filter 4
VHR	99.8	99.7	99.5	99.4
ID	16	19	40	55
Burn-in	Excellent	Excellent	Excellent	Excellent

[0216] The liquid crystal display apparatuses of Examples 157 to 160 had a high VHR and a small ID. Furthermore, a residual image was absent in the burn-in evaluation.

Claims

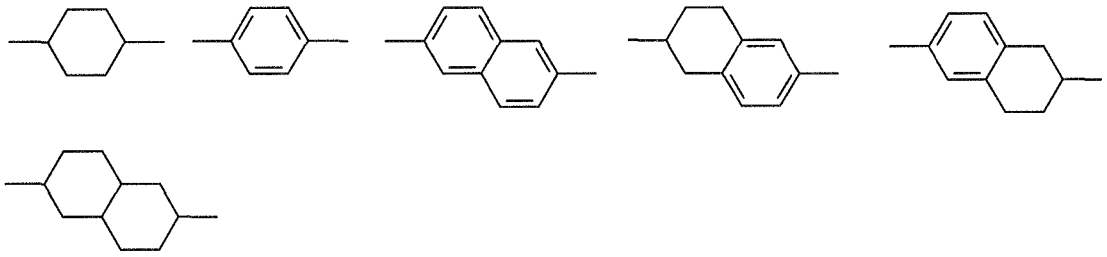
1. A liquid crystal display apparatus comprising a first substrate, a second substrate, a liquid crystal composition layer held between the first substrate and the second substrate, a color filter including a black matrix and at least RGB three-color pixel portions, a pixel electrode, and a common electrode,
wherein the liquid crystal composition layer is composed of a liquid crystal composition including one or more compounds selected from a group consisting of compounds represented by General Formula (LC1) and General Formula (LC2), the amount of the one or more compounds being more than 90% by mass of the total amount of liquid crystal compounds having a dielectric anisotropy of 2 or more,

[Chem. 1]



(where R_1 represents an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, -COO-, -C≡C-, - CF_2O-, or -OCF_2- in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; one or more hydrogen atoms of the alkyl group may optionally be replaced by a halogen; A_1 and A_2 each independently represent any one of the following structures:

[Chem. 2]



(in these structures, one or more CH_2 groups of the cyclohexane ring may be replaced by an oxygen atom, one or more CH groups of the benzene ring may be replaced by a nitrogen atom, and one or more hydrogen atoms may be replaced by Cl, F, CF_3, or OCF_3); X_1 to X_5 each independently represent H, Cl, F, CF_3, or OCF_3; Y represents Cl, F, CF_3, or OCF_3; Z_1 to Z_3 each independently represent a single bond,-CH=CH-, -C=C-, $-CH_2CH_2-$, $-(CH_2)_4-$, $-OCH_2-$, $-CH_2O-$, $-OCF_2-$, or $-CF_2O-$; m_1 and m_2 are each independently an integer of 0 to 3; and $m_1 + m_2$ is 1, 2, or 3), and
wherein the RGB three-color pixel portions include, as a coloring material, a pigment having a water-soluble content of 0% by mass or more and 1.5% by mass or less and/or a specific electrical conductivity of 10 μS/cm or more and 150 μS/cm or less.

2. The liquid crystal display apparatus according to Claim 1, wherein the RGB three-color pixel portions include, as a coloring material, a pigment having a water-soluble content of 0% by mass or more and 1.0% by mass or less and a specific electrical conductivity of 10 μS/cm or more and 100 μS/cm or less.

3. The liquid crystal display apparatus according to Claim 1 or 2, wherein the RGB three-color pixel portions include an R pixel portion including, as a coloring material, a diketopyrrolopyrrole-based red pigment; a G pixel portion including, as a coloring material, a halogenated metal phthalocyanine pigment; and a B pixel portion including, as a coloring material, an ε-type phthalocynian pigment and/or a triarylmethane pigment.

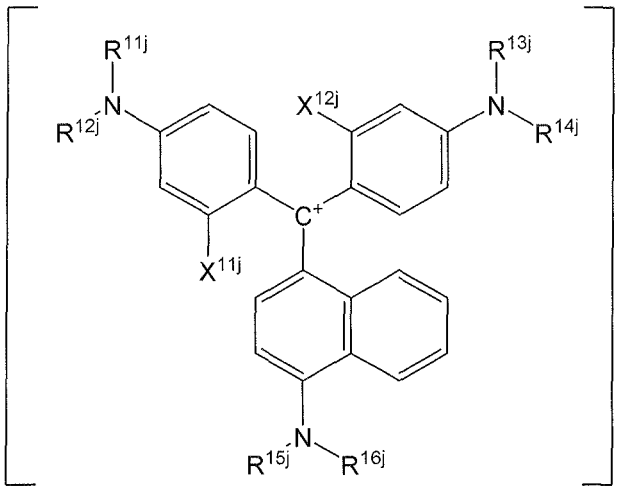
4. The liquid crystal display apparatus according to Claim 3,
wherein the halogenated metal phthalocyanine pigment included in the G pixel portion includes, as a central metal, a metal selected from the group consisting of Al, Si, Sc, Ti, V, Mg, Fe, Co, Ni, Zn, Cu, Ga, Ge, Y, Zr, Nb, In, Sn, and Pb, wherein, when the central metal is trivalent, one group selected from a halogen atom, a hydroxyl group, and a sulfonic group is bonded to the central metal or the central metal is oxo-cross-linked or thio-cross-linked, and
wherein, when the central metal is a tetravalent metal, one oxygen atom or two identical or different groups selected from a halogen atom, a hydroxyl group, and a sulfonic group are bonded to the central metal.

5. The liquid crystal display apparatus according to Claim 3 or 4, wherein the halogenated metal phthalocyanine pigment included in the G pixel portion is C.I. Pigment Green 58.

6. The liquid crystal display apparatus according to any one of Claims 3 to 5, wherein the ε-type phthalocynian pigment included in the B pixel portion is C.I. Pigment Blue 15:6.

7. The liquid crystal display apparatus according to any one of Claims 3 to 6, wherein the triarylmethane pigment included in the B pixel portion includes C.I. Pigment Blue 1 and/or a triarylmethane pigment represented by General Formula (1),

[Chem. 3]



(1)

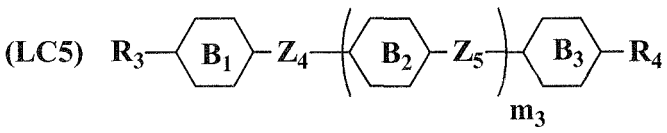
(where R^{11j} to R^{16j} each independently represent a hydrogen atom, an alkyl group having 1 to 8 carbon atoms which may be substituted, or an aryl group which may be substituted; when R^{11j} to R^{16j} represent an alkyl group which may be substituted, adjacent R^{11j} and R^{12j}, adjacent R^{13j} and R^{14j}, and adjacent R^{15j} and R^{16j} may be each bonded to each other to form a ring structure; X^{11j} and X^{12j} each independently represent a hydrogen atom, a halogen atom, or an alkyl group having 1 to 8 carbon atoms which may be substituted; Z^- is at least one anion selected from a heteropolyoxometalate anion represented by $(P_2Mo_yW_{18-y}O_{62})^{6-}/6$ where y is an integer of 0, 1, 2, or 3, a heteropolyoxometalate anion represented by $(SiMoW_{11}O_{40})^{4-}/4$, and a lacunary Dawson-type phosphotungstic acid heteropolyoxometalate anion; and, when one molecule includes a plurality of structures represented by Formula (1), the structures may be identical or different).

8. The liquid crystal display apparatus according to any one of Claims 3 to 7, wherein the diketopyrrolopyrrole-based red pigment included in the R pixel portion includes one or more pigments selected from C.I. Pigment Red 254, C.I. Pigment Red 255, C.I. Pigment Red 264, C.I. Pigment Red 272, C.I. Pigment Orange 71, and C.I. Pigment Orange 73.

9. The liquid crystal display apparatus according to any one of Claims 1 to 8, wherein the color filter includes the black matrix, the RGB three-color pixel portions, and a Y pixel portion including, as a coloring material, a pigment having a water-soluble content of 1.5% or less and/or a specific electrical conductivity of 150 μS/cm or less.

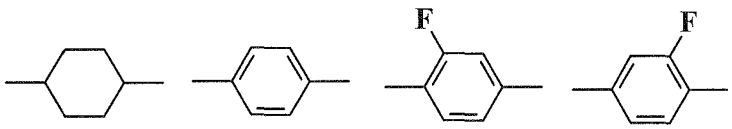
10. The liquid crystal display apparatus according to any one of Claims 1 to 9, wherein the liquid crystal composition layer is composed of a liquid crystal composition including one or more compounds represented by General Formula (LC5),

[Chem. 4]



(where R_3 and R_4 each independently represent an alkyl group having 1 to 15 carbon atoms; one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, -COO-, -C=C-, $-CF_2O-$, or $-OCF_2-$ in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; one or more hydrogen atoms of the alkyl group may optionally be replaced by a halogen; B_1 to B_3 each independently represent any one of the following structures:

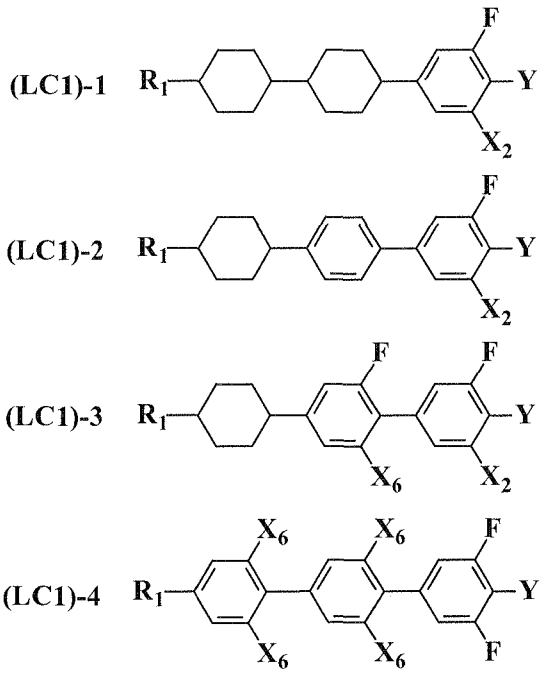
[Chem. 5]



(in these structures, one or more CH_2CH_2 groups of the cyclohexane ring may be replaced by -CH=CH-, $-CF_2O-$, or-OCF_2- and one or more CH groups of the benzene ring may be replaced by a nitrogen atom); Z_4 and Z_5 each independently represent a single bond, -CH=CH-, -CF=CF-, -C≡C-, $-CH_2CH_2-$,$-(CH_2)_4-$, -COO-, $-OCH_2-$, $-CH_2O-$ $-OCF_2-$, or $-CF_2O-$; and m_3 is 0 to 3) .

11. The liquid crystal display apparatus according to any one of Claims 1 to 10, wherein the compound represented by General Formula (LC-1) is one or more compounds selected from a group consisting of compounds represented by General Formula (LC1)-1 to General Formula (LC1)-4,

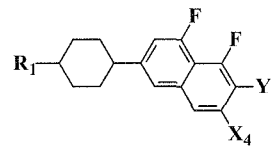
[Chem. 6]

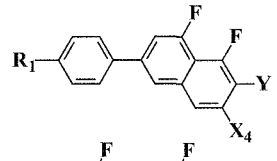


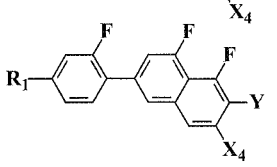
(where R_1 represents an alkyl group having 1 to 15 carbon atoms, one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, -COO-, -C=C-, - CF_2O-, or $-OCF_2-$ in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; X_2 and X_6 each independently represent a hydrogen atom, Cl, F, CF_3, or OCF_3; when a plurality of X_6's are present, they may be identical or different; and Y represents Cl, F, CF_3, OCH_2F, $OCHF_2$, or OCF_3).

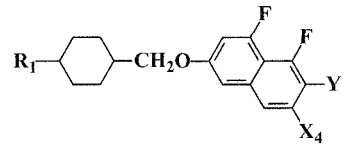
12. The liquid crystal display apparatus according to any one of Claims 1 to 11, wherein the compound represented by General Formula (LC2) is one or more compounds selected from a group consisting of compounds represented by General Formula (LC2)-1 to General Formula (LC2)-11,

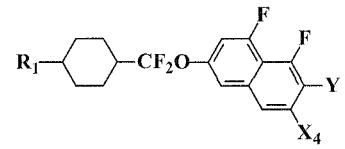
[Chem. 7]

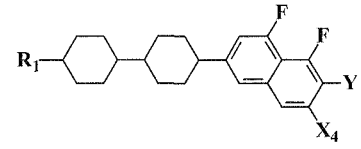
(LC2)-1 

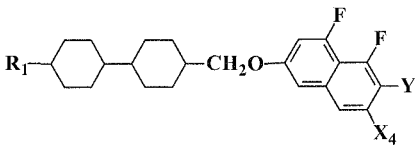
(LC2)-2 

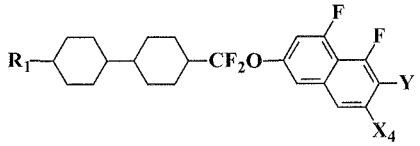
(LC2)-3 

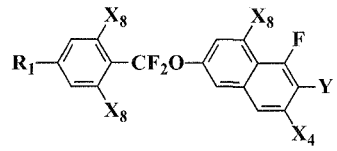
(LC2)-4 

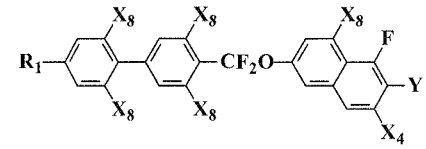
(LC2)-5 

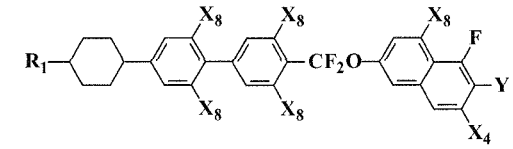
(LC2)-6 

(LC2)-7 

(LC2)-8 

(LC2)-9 

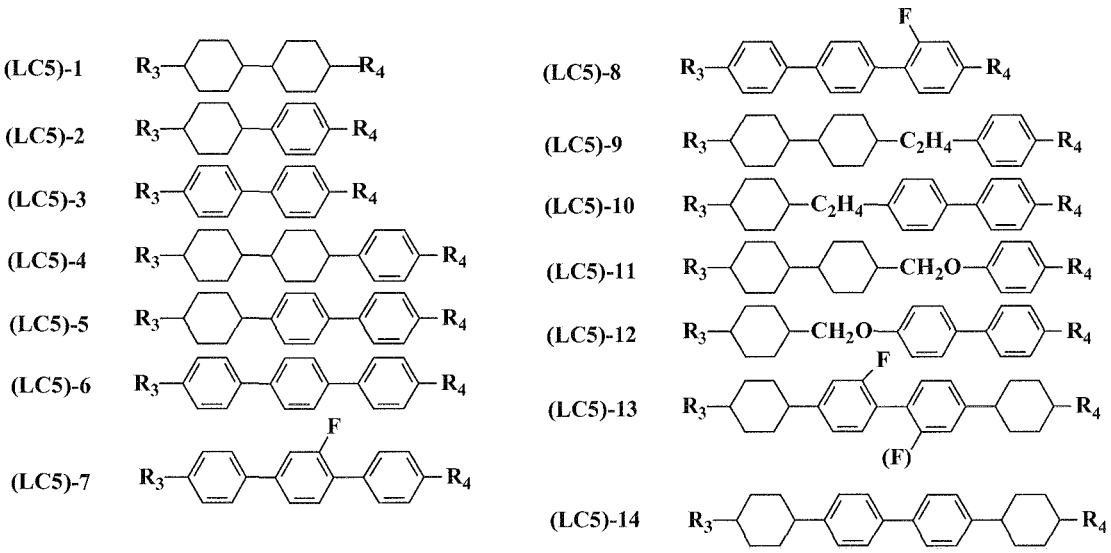
(LC2)-10 

(LC2)-11 

(where R_1 represents an alkyl group having 1 to 15 carbon atoms, one or more CH_2 groups of the alkyl group may be replaced by -O-, -CH=CH-, -CO-, -OCO-, -COO-, -C≡C-, - CF_2O-, or -OCF_2- in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; X_4 and X_8 each independently represent a hydrogen atom, Cl, F, CF_3, or OCF_3; when a plurality of X_8's are present, they may be identical or different; and Y represents Cl, F, CF_3, OCH_2F, $OCHF_2$, or OCF_3).

13. The liquid crystal display apparatus according to any one of Claims 1 to 12, wherein the compound represented by General Formula (LC5) is one or more compounds selected from a group consisting of compounds represented by General Formula (LC5)-1 to General Formula (LC5)-14,

[Chem. 8]



(where R_3 and R_4 each independently represent an alkyl group having 1 to 7 carbon atoms, an alkoxy group having 1 to 7 carbon atoms, an alkenyl group having 2 to 7 carbon atoms, or an alkenyloxy group having 2 to 7 carbon atoms).

14. The liquid crystal display apparatus according to any one of Claims 1 to 13, wherein the liquid crystal composition layer is composed of a polymer prepared by polymerizing a liquid crystal composition including one or more polymerizable compounds.

15. The liquid crystal display apparatus according to Claim 14, wherein the one or more polymerizable compounds are represented by General Formula (PC1),

[Chem. 9]

$$\text{(PC1)} \quad \left(P_1\text{—}Sp_1\text{-}Q_1\text{-}\right)_{n_1}MG\text{-}\left(R_{10}\right)_{n_2}$$

(where P_1 represents a polymerizable functional group; Sp_1 represents a spacer group having 0 to 20 carbon atoms; Q_1 represents a single bond, -O-, -NH-, -NHCOO-, -OCONH-, - CH=CH-, -CO-, -COO-, -OCO-, -OCOO-, -OOCO-, -CH=CH-, -CH=CH-COO-, -OCO-CH=CH-, or -C≡C-; n_1 and n_2 are 1, 2, or 3; MG represents a mesogenic group or a mesogenic supporting group; R_{10} represents a halogen atom, a cyano group, or an alkyl group having 1 to 25 carbon atoms, and one or more CH_2 groups of the alkyl group may be replaced by -O-, -S-, -NH-, -N(CH_3)-, -CO-, -COO-, -OCO-, -OCOO-, -SCO-, -COS-, or -C≡C-in such a manner that an oxygen atom is not directly adjacent to another oxygen atom; and, in another case, R_{10} represents P_2-Sp_2-Q_2- (where P_2, Sp_2, Q_2 independently represent the same things as P_1, Sp_1, Q_1, respectively)).

FIG. 1

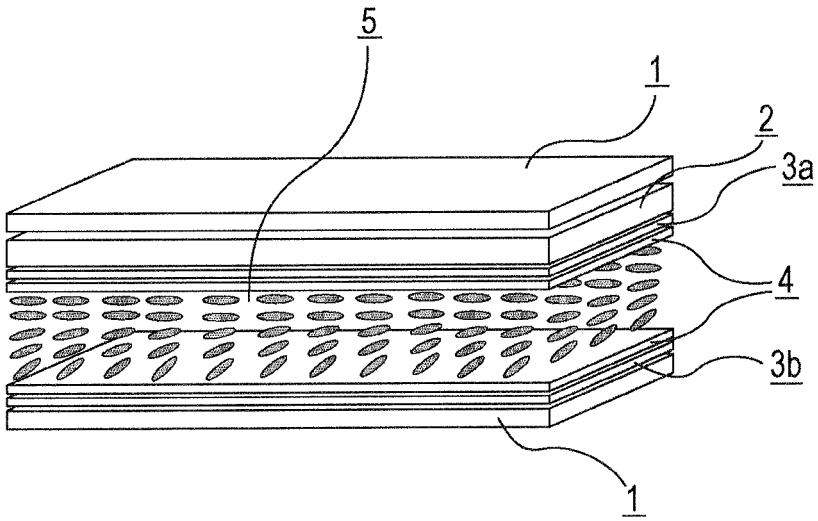
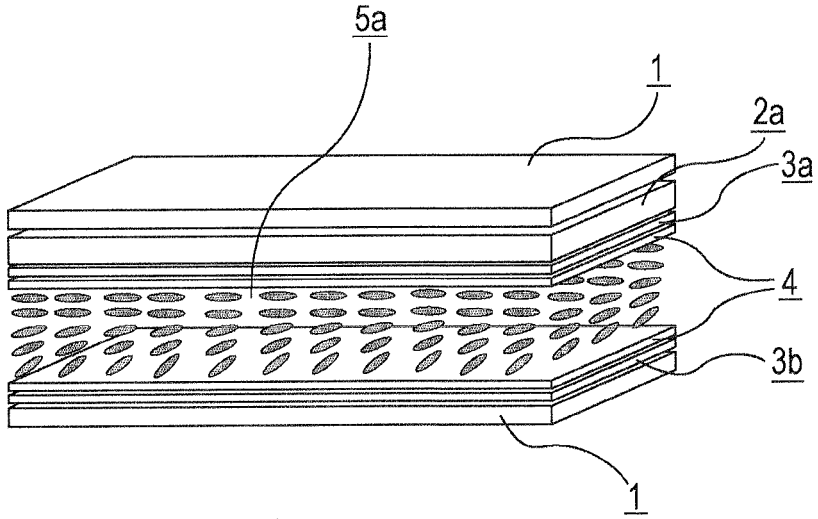


FIG. 2



INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/081728

A. CLASSIFICATION OF SUBJECT MATTER
G02F1/1335(2006.01)i, *C09K19/12*(2006.01)i, *C09K19/20*(2006.01)i, *C09K19/30*(2006.01)i, *C09K19/32*(2006.01)i, *C09K19/42*(2006.01)i, *G02B5/20*(2006.01)i, *G02F1/13*(2006.01)i
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
G02F1/1335, C09K19/12, C09K19/20, C09K19/30, C09K19/32, C09K19/42, G02B5/20, G02F1/13

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
Jitsuyo Shinan Koho 1922-1996 Jitsuyo Shinan Toroku Koho 1996-2014
Kokai Jitsuyo Shinan Koho 1971-2014 Toroku Jitsuyo Shinan Koho 1994-2014

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2000-192040 A (Toshiba Corp.), 11 July 2000 (11.07.2000), entire text (Family: none)	1-15
A	JP 2011-141356 A (Toppan Printing Co., Ltd.), 21 July 2011 (21.07.2011), entire text (Family: none)	1-15
A	JP 2010-189560 A (Toppan Printing Co., Ltd.), 02 September 2010 (02.09.2010), entire text (Family: none)	1-15

☒ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:
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"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed
"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
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"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
10 February, 2014 (10.02.14)	18 February, 2014 (18.02.14)
Name and mailing address of the ISA/ Japanese Patent Office Facsimile No.	Authorized officer Telephone No.

Form PCT/ISA/210 (second sheet) (July 2009)

INTERNATIONAL SEARCH REPORT

International application No.
PCT/JP2013/081728

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	JP 2006-317602 A (Fujifilm Corp.), 24 November 2006 (24.11.2006), entire text & US 2006/0257763 A1 & KR 10-2006-0116751 A	1-15

Form PCT/ISA/210 (continuation of second sheet) (July 2009)

REFERENCES CITED IN THE DESCRIPTION

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Patent documents cited in the description

- JP 2000019321 A **[0011]**
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- JP 2009007432 A **[0011]**
- JP 2008144105 A **[0011]**
- JP 2010260997 A **[0011]**
- JP 2004292785 A **[0157] [0164]**

专利名称(译)	液晶显示装置		
公开(公告)号	EP2930554A1	公开(公告)日	2015-10-14
申请号	EP2013860896	申请日	2013-11-26
[标]申请(专利权)人(译)	大日本油墨化学工业株式会社		
申请(专利权)人(译)	DIC株式会社		
当前申请(专利权)人(译)	DIC株式会社		
[标]发明人	KANEOYA MASAKAZU TAKEUCHI KIYOFUMI FUNAKURA SEIJI OSHIUMI ISAO SHIMADA KATSUNORI		
发明人	KANEOYA MASAKAZU TAKEUCHI KIYOFUMI FUNAKURA SEIJI OSHIUMI ISAO SHIMADA KATSUNORI		
IPC分类号	G02F1/1335 C09K19/12 C09K19/20 C09K19/30 C09K19/32 C09K19/42 G02B5/20 G02F1/13 C09K19/04 C09K19/52 C09K19/54 C09K19/60		
CPC分类号	G02F1/133514 C09K19/2014 C09K19/3001 C09K19/3066 C09K19/322 C09K19/542 C09K19/60 C09K2019/0448 C09K2019/0466 C09K2019/122 C09K2019/123 C09K2019/3004 C09K2019/301 C09K2019/3016 C09K2019/3021 C09K2019/3036 C09K2019/3037 C09K2019/304 C09K2019/523 G02F1/13 G02F1/133512		
优先权	2013126575 2013-06-17 JP 2012265199 2012-12-04 JP		
其他公开文献	EP2930554B1 EP2930554A4		
外部链接	Espacenet		

摘要(译)

液晶显示装置技术领域本发明涉及包含特定液晶组合物的液晶显示装置和包含特定颜料的滤色器。本发明提供一种液晶显示装置，其可以限制液晶层的电压保持率（VHR）的降低并且限制液晶层中的离子密度（ID）的增加并且解决诸如错误显示的问题。作为白色缺失像素，对齐不一致和老化。具有限制液晶层的电压保持率（VHR）的降低和限制液晶层中的离子密度（ID）的增加从而减少诸如老化等故障显示的发生的特征。根据本发明的液晶显示装置可以特别适合用作有源矩阵驱动的VA模式或PSVA模式液晶显示装置，并且可以用作包括在液晶TV中的液晶显示装置，监视器，移动电话，智能电话等。

FIG. 2