

DESCRIPTION

Title of Invention: OPTICAL STYRENE-BASED RESIN COMPOSITION, MOLDED BODY, LIGHT GUIDE PLATE, AND EDGE-LIGHT TYPE PLANAR LIGHT SOURCE UNIT

Technical Field

[0001]

The present invention relates to an optical styrene-based resin composition, a molded body, a light guide plate, and an edge-light type planar light source unit.

Background Art

[0002]

Backlights for liquid crystal display devices include a direct-light type, in which a light source is placed in front of the display device, and an edge-light type, in which a light source is placed on a side surface of the display device. Edge-light type backlights use a component called a light guide plate that guides light from the light source placed on the side surface to the front of the display device. They are used in a wide range of applications such as televisions, monitors for desktop personal computers, notebook personal computers, mobile phones, and monitors for car navigation systems. Backlights using a light guide plate are also used as lighting devices, signboards, and the like.

[0003]

Since the light guide plate has a relatively long light transmission distance and a large optical loss over the optical path length, it is required to have a particularly high light transmittance. For this reason, an acrylic resin represented by polymethyl methacrylate (PMMA) is used as a material for the light guide plate. However, since PMMA has high water absorption, warpage or dimensional change of the light guide plate may occur due to water absorption. In addition, since it is easily thermally decomposed during molding, there is a problem that appearance defects are likely to occur in a molded body when molded at high temperatures. To solve these problems, for example, Patent Literature 1 proposes using a styrene-methyl (meth)acrylate copolymer as a material for a light guide plate.

[0004]

On the other hand, a molded body of styrene-methyl (meth)acrylate copolymer has a poorer hue than PMMA, and when used as a backlight, color unevenness may occur. To solve this problem, Patent Literature 2 proposes a technique for improving the hue of styrene-methyl (meth)acrylate.

Citation List

Patent Literature

[0005]

[Patent Literature 1] JP-A-2003-075648

Summary of Invention

Technical Problem

[0006]

In recent years, with the increase in resolution of backlight units for televisions, monitors, and the like, high-brightness LEDs are sometimes used as edge light sources. However, in conventional light guide plates made of styrene-methyl (meth)acrylate copolymer, deterioration (yellowing) of the end face part of the light guide plate could occur after long-term lighting, depending on the usage environment. In addition, in recent years, displays that use mini-LEDs with higher-energy blue light as a light source and perform color conversion with QDs (quantum dots) have appeared, and the light stability required for light guide plates has become more sophisticated.

[0007]

The present invention has been made in view of such problems, and an object thereof is to provide an optical styrene-based resin composition that has excellent light stability against long-term use of a semiconductor light source such as an LED light source.

Solution to Problem

[0008]

As a result of diligent studies to solve the above problems, the present inventors have found that the above problems can be solved by setting a content of a styrene-based monomer and a total content of a styrene-based monomer linear dimer and a styrene-based monomer linear trimer in a styrene-based resin composition within a specified range, thereby completing the present invention.

[0009]

The following inventions are provided:

[1] An optical styrene-based resin composition comprising a styrene-based resin, wherein with respect to 1 g of the optical styrene-based resin composition:

a content of a styrene-based monomer is 1000 μg or less; and

a total content of a styrene-based monomer linear dimer and a styrene-based monomer linear trimer is 10 to 500 μg .

[2] The optical styrene-based resin composition of [1], wherein the styrene-based resin is a copolymer comprising 95 to 20 mass% of a styrene-based monomer unit and 5 to 80 mass% of a (meth)acrylic acid ester-based monomer unit.

[3] The optical styrene-based resin composition of [1] or [2], wherein a content of a phosphorus atom is 50 μg or less with respect to 1 g of the optical styrene-based resin composition.

[4] The optical styrene-based resin composition of any one of [1] to [3], satisfying a following formula (1),

wherein M (μg) is the content of the styrene-based monomer, D (μg) is a content of the styrene-based monomer linear dimer, T (μg) is a content of the styrene-based monomer linear trimer, and P (μg) is a content of a phosphorus atom, with respect to 1 g of the optical styrene-based resin composition.

$$(M + D + T) \times P \leq 20000 \quad (1)$$

[5] The optical styrene-based resin composition of any one of [1] to [4], comprising 0.001 to 0.5 parts by mass of a hindered amine light stabilizer with respect to 100 parts by mass of the styrene-based resin.

[6] The optical styrene-based resin composition of any one of [1] to [5], for use in transmitting light from an LED light source having a maximum emission intensity in a wavelength region of 400 nm to 500 nm.

[7] A molded body composed of the optical styrene-based resin composition of any one of [1] to [6].

[8] A light guide plate comprising the molded body of [7].

[9] An edge-light type planar light source unit, comprising the light guide plate of [8], and a light source which supplies LED light to an end face of the light guide plate.

Brief Description of Drawings

[0010]

Fig.1 is a diagram illustrating the shape of a plate-shaped test piece 1.

Description of Embodiments

[0011]

Embodiments of the present invention will be described below. Various distinctive features shown in the following embodiments can be combined with each other. In addition, an invention can be established independently for each of the distinctive features.

[0012]

1. Optical Styrene-based Resin Composition

The optical styrene-based resin composition according to an embodiment of the present invention comprises a styrene-based resin (A).

<Styrene-based Resin (A)>

The styrene-based resin (A) is a resin obtained by polymerizing raw material monomers including a styrene-based monomer. The styrene-based resin (A) is preferably a resin obtained by copolymerizing monomers including a styrene-based monomer and a (meth)acrylic acid ester-based

monomer. The styrene-based resin (A) is preferably a copolymer comprising a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit (styrene-acrylic acid ester-based copolymer). The styrene-acrylic acid ester-based copolymer comprises 95 to 20 mass% of the styrene-based monomer unit and 5 to 80 mass% of the (meth)acrylic acid ester-based monomer unit, preferably comprises 90 to 25 mass% of the styrene-based monomer unit and 10 to 75 mass% of the (meth)acrylic acid ester-based monomer unit, more preferably comprises 80 to 30 mass% of the styrene-based monomer unit and 20 to 70 mass% of the (meth)acrylic acid ester-based monomer unit, and even more preferably comprises 60 to 40 mass% of the styrene-based monomer unit and 40 to 60 mass% of the (meth)acrylic acid ester-based monomer unit, with respect to 100 mass% of the styrene-acrylic acid ester-based copolymer. By setting the contents of the monomer units within such ranges, transparency, hue, and dimensional stability can be satisfied simultaneously. By setting the content of the styrene-based monomer unit to 90 mass% or less, a molded body (such as a light guide plate) with excellent transparency and hue can be obtained, and by setting the content of the styrene-based monomer unit to 20% or more, a molded body with excellent dimensional stability can be obtained. The content of the (meth)acrylic acid ester-based monomer unit in the styrene-based resin (A) is, for example, 5, 6, 7, 8, 9, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, or 80 mass%, and may be within a range between any two of the values exemplified herein.

[0013]

Examples of the styrene-based monomer include, for example, styrene, α -methylstyrene, o-methylstyrene, p-methylstyrene, m-methylstyrene, ethylstyrene, p-t-butylstyrene and the like. These can be used alone or in combination of two or more. The styrene-based monomer is preferably styrene.

[0014]

Examples of the (meth)acrylic acid ester-based monomer include, for example, alkyl (meth)acrylates such as methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, t-butyl (meth)acrylate, isoamyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, and lauryl (meth)acrylate; aryl (meth)acrylates such as phenyl (meth)acrylate and benzyl (meth)acrylate; cycloalkyl (meth)acrylates such as cyclohexyl (meth)acrylate, 4-t-butylcyclohexyl (meth)acrylate, 2-norbornyl (meth)acrylate, isobornyl (meth)acrylate, adamant-1-yl (meth)acrylate, 2-methyladamant-2-yl (meth)acrylate, 2-ethyl-2-adamantyl (meth)acrylate, and tricyclodecanyl (meth)acrylate; glycidyl (meth)acrylate; dicyclopentanyl (meth)acrylate, and the like. These can be used alone or in combination of two or more. The (meth)acrylic acid ester-based monomer is preferably alkyl (meth)acrylate, and more preferably methyl methacrylate.

[0015]

The styrene-based resin (A) may also be a copolymer obtained by copolymerizing with other copolymerizable monomers with the styrene-based monomer and the (meth)acrylic acid ester-based

monomer. Examples of the other copolymerizable monomer include, for example, (meth)acrylic acids such as acrylic acid and methacrylic acid; vinyl cyanides such as acrylonitrile and methacrylonitrile; α,β -ethylene unsaturated carboxylic acids such as maleic anhydride and fumaric acid; and imides such as phenylmaleimide and cyclohexylmaleimide. These can be used alone or in combination of two or more.

[0016]

The weight average molecular weight (M_w) of the styrene-based resin (A) is preferably 50,000 to 400,000, and more preferably 100,000 to 350,000. The ratio (M_w/M_n) of the weight average molecular weight (M_w) to the number average molecular weight (M_n) of the styrene-based resin (A) is preferably 3.5 or less, more preferably 1.0 to 3.5, and even more preferably 1.5 to 3.0. By setting the weight average molecular weight within such ranges, both moldability and strength of the light guide plate can be achieved. When the weight average molecular weight (M_w) is less than 50,000, the strength of the molded product may be insufficient, and when it exceeds 400,000, the moldability may decrease. When the ratio of the weight average molecular weight (M_w) to the number average molecular weight (M_n) (M_w/M_n) exceeds 3.5, the strength of the molded product may decrease.

[0017]

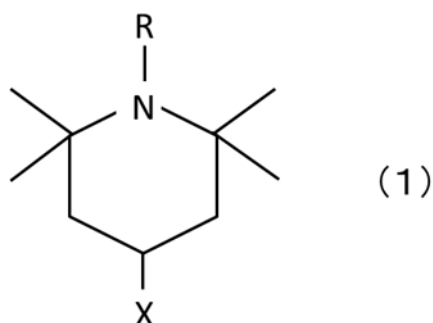
<Hindered Amine Light Stabilizer>

The optical styrene-based resin composition preferably comprises 0.001 to 1.0 part by mass, more preferably 0.001 to 0.5 parts by mass, and even more preferably 0.05 to 0.3 parts by mass of the hindered amine light stabilizer (B) with respect to 100 parts by mass of the styrene-based resin (A). By setting the content of the hindered amine light stabilizer (B) within such ranges, light stability can be improved. The content of the hindered amine light stabilizer (B) with respect to 100 parts by mass of the styrene-based resin (A) is, for example, 0.001, 0.005, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, or 1.0 parts by mass, and may be within a range between any two of the values exemplified herein. The hindered amine light stabilizer (B) may be used alone or in combination of two or more.

[0018]

The hindered amine light stabilizer (B) is a compound having a structural unit represented by the following general formula (1).

[0019]



[0020]

In the general formula (1), X is an organic group bonded to the 4-position of the piperidyl group via a carbon atom, an oxygen atom, or a nitrogen atom, and R includes a hydrogen atom, a linear or branched alkyl group having 1 to 10 carbon atoms, a methylene group, and an alkoxy group. Here, the case where R is a hydrogen atom is referred to as an N-H type hindered amine light stabilizer, the case where R is a linear or branched alkyl group having 1 to 10 carbon atoms or a methylene group is referred to as an N-R type hindered amine light stabilizer, and the case where R is an alkoxy group is referred to as an N-OR hindered amine type light stabilizer.

[0021]

Examples of the N-H type hindered amine light stabilizer include bis(2,2,6,6-tetramethylpiperidin-4-yl) sebacate (TINUVIN 770DF, manufactured by BASF), 2,2,6,6-tetramethyl-4-piperidyl hexadecanoate, 2,2,6,6-tetramethyl-4-piperidyl octadecanoate (SABOSTAB UV91, manufactured by SONGWON), tetrakis(2,2,6,6-tetramethyl-4-piperidyl)-1,2,3,4-butanetetracarboxylate (ADK STAB LA-57, manufactured by ADEKA), a polycondensate of N,N'-bis(2,2,6,6-tetramethylpiperidin-4-yl)hexamethylenediamine and 4-morpholino-2,6-dichloro-1,3,5-triazine (SABOSTAB UV79, manufactured by SONGWON), a polycondensate of 2,4-dichloro-6-(1,1,3,3-tetramethylbutylamino)-1,3,5-triazine and N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine (Chimassorb 944FDL, manufactured by BASF), a polycondensate of N,N'-bis(2,2,6,6-tetramethylpiperidin-4-yl)hexamethylenediamine, 2,4,6-trichloro-1,3,5-triazine, N-butyl-1-butanamine, and N-butyl-2,2,6,6-tetramethyl-4-piperidineamine (SABOSTAB UV40, manufactured by SONGWON), 1,6,11-tris[2,4-bis(N-butyl-N-(2,2,6,6-tetramethyl-4-piperidyl)amino)-s-triazin-6-yl]aminoundecane (Chimassorb 2020FDL, manufactured by BASF), a polycondensate of 1,2,3,4-butanetetracarboxylic acid, 2,2,6,6-tetramethyl-4-piperidinol, and $\beta,\beta,\beta',\beta'$ -tetramethyl-2,4,8,10-tetraoxaspiro[5.5]undecane-3,9-diethanol (ADK STAB LA-68, manufactured by ADEKA), dodecyl 3-(2,2,4,4-tetramethyl-21-oxo-7-oxa-3,20-diazadispiro(5.1.11.2)henicosan-20-yl)propionate, tetradecyl 3-(2,2,4,4-tetramethyl-21-oxo-7-oxa-3,20-diazadispiro(5.1.11.2)henicosan-20-yl)propionate (HOSTAVIN 3030, manufactured by CLARIANT), and a polycondensate of 2,2,4,4-tetramethyl-7-oxa-3,20-diazadispiro-(5.1.11.2)henicosan-21-one and epichlorohydrin (HOSTAVIN

N30P, manufactured by CLARIANT).

[0022]

Examples of the N-R type hindered amine light stabilizer include methyl (1,2,2,6,6-pentamethylpiperidin-4-yl) sebacate, bis(1,2,2,6,6-pentamethylpiperidin-4-yl) sebacate (TINUVIN 292, TINUVIN 765, manufactured by BASF), bis(1,2,2,6,6-pentamethylpiperidin-4-yl) n-butyl-3,5-di-tert-butyl-4-hydroxybenzylmalonate (TINUVIN 144, manufactured by BASF), a polycondensate of 4-hydroxy-2,2,6,6-tetramethyl-1-piperidineethanol and dimethyl succinate (TINUVIN 622SF, manufactured by BASF), 1,5,8,12-tetrakis[4,6-bis(N-butyl-N-(1,2,2,6,6-pentamethyl-4-piperidyl)amino)-1,3,5-triazin-2-yl]-1,5,8,12-tetraazadodecane (Chimassorb 119, manufactured by BASF), a polycondensate of 1,2,3,4-butanetetracarboxylic acid, 1,2,2,6,6-pentamethyl-4-piperidinol, and $\beta,\beta,\beta',\beta'$ -tetramethyl-2,4,8,10-tetraoxaspiro[5.5]undecane-3,9-diethanol (ADK STAB LA-63P, manufactured by ADEKA), and a mixture of a polycondensate of succinic acid and (4-hydroxy-2,2,6,6-tetramethylpiperidin-1-yl)ethanol and N,N',N'',N'''-tetrakis-(4,6-bis-(butyl-(N-methyl-2,2,6,6-tetramethylpiperidin-4-yl)amino)-triazin-2-yl)-4,7-diazadecane-1,10-diamine (TINUVIN 111FDL, manufactured by BASF).

[0023]

Examples of the N-OR type hindered amine light stabilizer include bis(1-octyloxy-2,2,6,6-tetramethylpiperidyl) sebacate (TINUVIN 123, manufactured by BASF), and bis(1-undecanoxo-2,2,6,6-tetramethylpiperidin-4-yl) carbonate (ADK STAB LA-81, manufactured by ADEKA).

[0024]

<Antioxidant (C)>

The optical styrene-based resin composition preferably comprises 0.001 to 0.5 parts by mass, more preferably 0.002 to 0.4 parts by mass, and even more preferably 0.005 to 0.3 parts by mass of the phosphorus-based antioxidant (C-1) with respect to 100 parts by mass of the styrene-based resin (A). By setting the content of the phosphorus-based antioxidant (C-1) within such ranges, good transparency and hue can be obtained. The content of the phosphorus-based antioxidant (C-1) with respect to 100 parts by mass of the styrene-based resin (A) is, for example, 0.001, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.009, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, or 0.5 parts by mass, and may be within a range between any two of the values exemplified herein.

[0025]

The phosphorus-based antioxidant (C-1) is a phosphorous ester or a phosphate ester that does not have a phenolic hydroxyl group in its basic skeleton, and is preferably a phosphite ester, which is a trivalent phosphorus compound. Examples of the phosphorus-based antioxidant (C-1) include 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy)(2-ethylhexyloxy)phosphorous, bis-(2,4-di-tert-butylphenyl)pentaerythritol diphosphite, tris(2,4-di-tert-butylphenyl) phosphite, 3,9-bis(2,6-di-tert-butyl-4-methylphenoxy)-2,4,8,10-tetraoxa-3,9-diphosphaspiro[5.5]undecane, tetrakis(2,4-di-tert-

butylphenyl)[1,1'-biphenyl]-4,4'-diylbisphosphonite, bis(2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite, and the like, and these can be used alone or in combination of two or more.

[0026]

The optical styrene-based resin composition preferably comprises 0.001 to 0.5 parts by mass, more preferably 0.002 to 0.4 parts by mass, and even more preferably 0.005 to 0.3 parts by mass of the phenolic antioxidant (C-2) with respect to 100 parts by mass of the styrene-based resin (A). When the content of the phenolic antioxidant (C-2) exceeds 0.5 parts by mass, the hue deteriorates, which is not preferable. The content of the phenolic antioxidant (C-2) with respect to 100 parts by mass of the styrene-based resin (A) is, for example, 0.001, 0.002, 0.003, 0.004, 0.005, 0.006, 0.007, 0.008, 0.009, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, or 0.5 parts by mass, and may be within a range between any two of the values exemplified herein.

[0027]

The phenolic antioxidant (C-2) is an antioxidant that has a phenolic hydroxyl group in its basic skeleton and is not a phosphorous ester or a phosphate ester. Examples of the phenolic antioxidant (C-2) include, for example, octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate, ethylenebis(oxyethylene)bis[3-(5-tert-butyl-4-hydroxy-m-tolyl)propionate], and pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], and these can be used alone or in combination of two or more.

[0028]

Among antioxidants, there are phosphorus-phenolic compounds that have both a phosphite structure and a phenol structure in the same molecule, such as 6-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propoxy]-2,4,8,10-tetra-tert-butyl-dibenzo[d,f][1,3,2]dioxaphosphin. In the case of such a compound, it is considered that the optical styrene-based resin composition contains both a phosphorus-based antioxidant and a phenolic antioxidant. For example, when 0.1 parts by mass of a phosphorus-phenolic compound is contained with respect to 100 parts by mass of the styrene-based resin (A), it is considered that 0.1 parts by mass of a phosphorus-based antioxidant and 0.1 parts by mass of a phenolic antioxidant are contained.

[0029]

<Monomer, Dimer, Trimer, and Phosphorus>

In the optical styrene-based resin composition, the content of the styrene-based monomer is 1000 µg or less, preferably 700 µg or less, and more preferably 500 µg or less, with respect to 1 g of the optical styrene-based resin composition. The lower limit of the content of the styrene-based monomer is not particularly limited, but is, for example, 1 µg or more. The content of the styrene-based monomer with respect to 1 g of the optical styrene-based resin composition is, for example, 0, 1, 10, 50, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800, 850, 900, 950, or 1000 µg, and may be within a range between any two of the values exemplified herein. By setting the

content of the styrene-based monomer within such ranges, the optical styrene-based resin composition is excellent in light stability.

[0030]

In the optical styrene-based resin composition, the total content (D+T) of the styrene-based monomer linear dimer and the styrene-based monomer linear trimer is 10 to 500 μg , preferably 400 μg or less, and more preferably 300 μg or less, with respect to 1 g of the optical styrene-based resin composition. The total content (D+T) with respect to 1 g of the optical styrene-based resin composition is, for example, 10, 50, 100, 150, 200, 250, 300, 330, 350, 400, 420, 450, or 500 μg , and may be within a range between any two of the values exemplified herein. By setting the total content (D+T) within such ranges, the optical styrene-based resin composition is excellent in light stability.

[0031]

In the optical styrene-based resin composition, the content of the styrene-based monomer linear dimer is preferably 500 μg or less, preferably 100 μg or less, and more preferably 50 μg or less, with respect to 1 g of the optical styrene-based resin composition. The lower limit of the content of the styrene-based monomer linear dimer with respect to 1 g of the optical styrene-based resin composition is not particularly limited, but is, for example, 1 μg or more. The content of the styrene-based monomer linear dimer with respect to 1 g of the optical styrene-based resin composition is, for example, 0, 1, 5, 10, 15, 20, 30, 40, 50, 60, 70, 80, 90, 100, 200, 300, 400, or 500 μg , and may be within a range between any two of the values exemplified herein. By setting the content of the styrene-based monomer linear dimer within such ranges, the optical styrene-based resin composition is excellent in light stability.

[0032]

In the optical styrene-based resin composition, the content of the styrene-based monomer linear trimer is preferably 500 μg or less, preferably 300 μg or less, and more preferably 200 μg or less, with respect to 1 g of the optical styrene-based resin composition. The lower limit of the content of the styrene-based monomer linear trimer with respect to 1 g of the optical styrene-based resin composition is not particularly limited, but is, for example, 10 μg or more. The content of the styrene-based monomer linear trimer with respect to 1 g of the optical styrene-based resin composition is, for example, 0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100, 110, 120, 130, 140, 150, 160, 170, 180, 190, 200, 210, 220, 230, 240, 250, 260, 270, 280, 290, 300, 350, 400, or 500 μg , and may be within a range between any two of the values exemplified herein. By setting the content of the styrene-based monomer linear trimer within such ranges, the optical styrene-based resin composition is excellent in light stability.

[0033]

In the optical styrene-based resin composition, the content of the phosphorus atom is preferably 100 μg or less, more preferably 50 μg or less, and even more preferably 20 μg or less, with

respect to 1 g of the optical styrene-based resin composition. The lower limit of the content of the phosphorus atom with respect to 1 g of the optical styrene-based resin composition is not particularly limited, but is, for example, 0 μg or more. The content of the phosphorus atom with respect to 1 g of the optical styrene-based resin composition is, for example, 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 25, 30, 40, 50, 60, 70, 80, 90, or 100 μg , and may be within a range between any two of the values exemplified herein. By setting the content of the phosphorus atom within such ranges, the optical styrene-based resin composition is excellent in light stability. The content of the phosphorus atom can be adjusted, for example, by the amount of the phosphorus antioxidant (C-1) added.

[0034]

The optical styrene-based resin composition preferably satisfies the following formula (1), wherein M (μg) is the content of the styrene-based monomer, D (μg) is the content of the styrene-based monomer linear dimer, T (μg) is the content of the styrene-based monomer linear trimer, and P (μg) is the content of the phosphorus atom, with respect to 1 g of the optical styrene-based resin composition. " $(M + D + T) \times P$ " is more preferably 15000 or less, and even more preferably 10000 or less. By setting the " $(M + D + T) \times P$ " within such ranges, the optical styrene-based resin composition is excellent in light stability.

$$(M + D + T) \times P \leq 20000 \quad (1)$$

[0035]

The method for measuring the content of the styrene-based monomer, the styrene-based monomer linear dimer, and the styrene-based monomer linear trimer in the optical styrene-based resin composition is not particularly limited, but for example, it can be measured using a gas chromatograph.

[0036]

In one example, when using a synthesized styrene-based resin (A), the weight of the styrene-based resin (A) before preparing the composition is accurately weighed, dissolved in tetrahydrofuran (THF) together with an internal standard substance (e.g., p-diethylbenzene), and the content of the styrene-based monomer is measured using a capillary gas chromatograph to calculate the content of the styrene-based monomer with respect to the styrene-based resin (A), and this is converted to the content (μg) in 1 g of the optical styrene-based resin composition using it. A calibration curve for the styrene-based monomer is prepared in advance and used for quantification.

[0037]

In another example, the weight of the optical styrene-based resin composition is accurately weighed, dissolved in tetrahydrofuran (THF) together with an internal standard substance (e.g., p-diethylbenzene), and the content of the styrene-based monomer is measured using a capillary gas chromatograph. A calibration curve for the styrene-based monomer is prepared in advance and used for quantification.

[0038]

In one example, when using a synthesized styrene-based resin (A), the content of the styrene-based monomer linear dimer and the styrene-based monomer linear trimer in the styrene-based resin (A) before preparing the composition can be measured by preparing the following measurement solution. The measurement solution is prepared by adding THF to the styrene-based resin (A), extracting by sonication, then adding hexane to precipitate the polymer, and after standing, concentrating the supernatant liquid. Then, the measurement solution is measured using a capillary gas chromatograph to calculate the content of the styrene-based monomer with respect to the styrene-based resin (A), and this is converted to the content (μg) in 1 g of the optical styrene-based resin composition using it. A styrene-based monomer linear dimer and a styrene-based monomer linear trimer are synthesized or obtained commercially, and calibration curves for them are prepared in advance and used for quantification.

[0039]

In another example, the content of the styrene-based monomer linear dimer and the styrene-based monomer linear trimer in the optical styrene-based resin composition can be measured by preparing the following measurement solution. The measurement solution is prepared by adding THF to the optical styrene-based resin composition, extracting by sonication, then adding hexane to precipitate the polymer, and after standing, concentrating the supernatant liquid. Then, the measurement solution is measured using a capillary gas chromatograph. A styrene-based monomer linear dimer and a styrene-based monomer linear trimer are synthesized or obtained commercially, and calibration curves for them are prepared in advance and used for quantification.

[0040]

Here, the styrene-based monomer linear dimer and the styrene-based monomer linear trimer are dimerized and trimerized products of the styrene-based monomer. These dimerized and trimerized products are, for example, derived from the styrene-based monomer used in the synthesis of the styrene-based resin (A) (e.g., by-products). As for the dimerized and trimerized products of the styrene-based monomer, there can be those formed by bonding in a linear manner (linear dimer and linear trimer) and those formed by bonding in a non-linear (e.g., cyclic) manner (non-linear dimer and non-linear trimer). In the present invention, the content of the styrene-based monomer linear dimer and the styrene-based monomer linear trimer, which are linear in the structure, is specified.

[0041]

When multiple types of styrene-based monomers are used, the styrene-based monomer linear dimer and the styrene-based monomer linear trimer may include, in addition to those in which the same type of styrene-based monomer is dimerized or trimerized, those in which two or three different types of styrene-based monomers are bonded.

[0042]

In the synthesis of the styrene-based resin (A), when styrene is used as the styrene-based monomer, 2,4-diphenyl-1-butene can be generated as the styrene-based monomer linear dimer, and 2,4,6-triphenyl-1-hexene can be generated as the styrene-based monomer linear trimer. In one embodiment where styrene is used as the styrene-based monomer, the optical styrene-based resin composition preferably has a styrene content of 1000 μg or less with respect to 1 g of the optical styrene-based resin composition, and a total content of 2,4-diphenyl-1-butene and 2,4,6-triphenyl-1-hexene of 10 to 500 μg . In one embodiment where styrene is used as the styrene-based monomer, the above-mentioned numerical ranges for the content of the styrene monomer, the total content of the styrene-based monomer linear dimer and the styrene-based monomer linear trimer, their respective contents, and the relationship of the above formula (1), etc., can be regarded as preferable numerical ranges for styrene, 2,4-diphenyl-1-butene, and 2,4,6-triphenyl-1-hexene.

[0043]

The content of the phosphorus atom can be obtained, for example, by calculating from the amount of a phosphorus-containing additive (such as the phosphorus-based antioxidant) added to the optical styrene-based resin composition. The content of the phosphorus atom may also be obtained by elemental analysis or ICP-AES (Inductively Coupled Plasma Atomic Emission Spectrometry) of the optical styrene-based resin composition, or by other analytical methods.

[0044]

<Other Components>

The content of t-butylcatechol (TBC) in the optical styrene-based resin composition is preferably 10 ppm or less, and more preferably 5 ppm or less. By setting the content of TBC within such ranges, a light guide plate with excellent hue and transmittance can be obtained. The content of TBC is, for example, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 ppm, and may be within a range between any two of the values exemplified herein.

[0045]

The content of 6-tert-butyl-2,4-xylenol (TBX) in the optical styrene-based resin composition is preferably 10 ppm or less, and more preferably 5 ppm or less. By setting the content of TBX within such ranges, a light guide plate with excellent hue and transmittance can be obtained. The content of TBX is, for example, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 1, 2, 3, 4, 5, 6, 7, 8, 9, or 10 ppm, and may be within a range between any two of the values exemplified herein.

[0046]

The optical styrene-based resin composition may contain, within a range that does not impair the properties of the present invention, a sulfur-based antioxidant, a lactone-based antioxidant, an ultraviolet absorber, an antistatic agent, a hydrophilic additive, liquid paraffin (mineral oil), polyethylene wax, microcrystalline wax, a bluing agent, and a release agent such as higher fatty acids like lauric acid, myristic acid, palmitic acid, and stearic acid, higher fatty acid amides like stearic acid

amide, erucic acid amide, and ethylene bis stearic acid amide, higher fatty acid glycerides like lauric acid monoglyceride, palmitic acid monoglyceride, stearic acid monoglyceride, and behenic acid monoglyceride, and higher alcohols like myristyl alcohol, cetyl alcohol, and stearyl alcohol.

[0047]

<Properties of Optical Styrene-based Resin Composition>

The melt mass flow rate (MFR) of the optical styrene-based resin composition under the conditions of a temperature of 200°C and a load of 49 N is preferably 0.5 to 5.0 g/10 min, and more preferably 1.0 to 4.0 g/10 min. When the MFR is less than 0.5 g/10 min, the molding stability decreases, and when the MFR exceeds 5.0 g/10 min, the strength becomes insufficient. The MFR is, for example, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, or 5.0 g/10 min, and may be within a range between any two of the values exemplified herein.

[0048]

The Vicat softening temperature of the optical styrene-based resin composition is preferably 95 to 104°C, and more preferably 100 to 104°C. When the Vicat softening temperature is less than 95°C, the heat resistance is insufficient, and the light guide plate may be deformed depending on the usage environment. The Vicat softening temperature is, for example, 95, 96, 97, 98, 99, 100, 101, 102, 103, or 104°C, and may be within a range between any two of the values exemplified herein.

[0049]

The average transmittance of the optical styrene-based resin composition at a wavelength of 380 to 780 nm with an optical path length of 115 mm of a molded body is preferably 85% or more, and more preferably 86% or more.

[0050]

The YI value of the optical styrene-based resin composition with an optical path length of 115 mm of a molded body is preferably 6.0 or less, and more preferably 4.0 or less.

[0051]

In the optical styrene-based resin composition, the rate of change calculated by the following formula for the dimensional change of the long side before and after storage for 500 hours under conditions of a temperature of 60°C and a relative humidity of 90% is preferably 0.15% or less, and more preferably less than 0.10%.

[0052]

In the optical styrene-based resin composition, the time until the yellowness index YI of a molded body exceeds 20 by blue LD irradiation is preferably 150 hours or more, more preferably 400 hours or more, and even more preferably 600 hours or more. Detailed conditions for the blue LD irradiation will be described in the Examples below.

[0053]

<Manufacturing Method of Optical Styrene-based Resin Composition>

As the polymerization method for the styrene-based resin (A), known styrene polymerization methods such as a bulk polymerization method, a solution polymerization method, a suspension polymerization method, and an emulsion polymerization method can be mentioned. In terms of quality and productivity, a bulk polymerization method and a solution polymerization method are preferable, and continuous polymerization is preferable. As a solvent, for example, alkylbenzenes such as benzene, toluene, ethylbenzene, and xylene, ketones such as acetone and methyl ethyl ketone, aliphatic hydrocarbons such as hexane and cyclohexane, and the like can be used.

[0054]

During the polymerization of the styrene-based resin (A), polymerization auxiliary agents such as polymerization initiators, chain transfer agents, and crosslinking agents, and other polymerization auxiliary agents can be used as necessary. As the polymerization initiator, a radical polymerization initiator is preferable, and known and conventional ones such as peroxyketals like 1,1-di(t-butylperoxy)cyclohexane, 2,2-di(t-butylperoxy)butane, 2,2-di(4,4-di-t-butylperoxycyclohexyl)propane, and 1,1-di(t-amylperoxy)cyclohexane; hydroperoxides such as cumene hydroperoxide and t-butyl hydroperoxide; alkyl peroxides such as t-amyl peroxyisooctanoate; dialkyl peroxides such as t-butyl cumyl peroxide, di-t-butyl peroxide, dicumyl peroxide, and di-t-hexyl peroxide; peroxyesters such as t-butyl peroxyacetate, t-butyl peroxybenzoate, and t-butyl peroxyisopropyl monocarbonate; peroxycarbonates such as t-butyl peroxyisopropyl carbonate and polyether tetrakis(t-butyl peroxy carbonate); and N,N'-azobis(cyclohexane-1-carbonitrile), N,N'-azobis(2-methylbutyronitrile), N,N'-azobis(2,4-dimethylvaleronitrile), N,N'-azobis[2-(hydroxymethyl)propionitrile] can be mentioned, and these can be used alone or in combination of two or more. As the chain transfer agent, aliphatic mercaptans such as n-dodecyl mercaptan and tert-dodecyl mercaptan, aromatic mercaptans, thiocarboxylic acids such as thioglycolic acid and mercaptopropionic acid, polyfunctional mercaptans obtained by esterifying polyhydric alcohol hydroxyl groups such as ethylene glycol, tetraethylene glycol, neopentyl glycol, trimethylolpropane, pentaerythritol, dipentaerythritol, tripentaerythritol, and sorbitol with thioglycolic acid or mercaptopropionic acid, pentaphenylethane, α -methylstyrene dimer, and terpinolene can be mentioned. Among them, aliphatic mercaptans, aromatic mercaptans, thiocarboxylic acids, and polyfunctional mercaptans are preferable in terms of easy adjustment of molecular weight.

[0055]

In the case of continuous polymerization, the styrene-based resin (A) can be produced by a method comprising a polymerization step, a devolatilization step, and a pelletizing step.

[0056]

First, in the polymerization step, a known complete mixing vessel type stirred tank or a tower type reactor is used, and the polymerization reaction is controlled by adjusting the polymerization temperature and the like to achieve the target molecular weight, molecular weight

distribution, and reaction conversion rate.

[0057]

The polymerization solution containing the polymer after the polymerization step is transferred to the devolatilization step, where unreacted monomers and the polymerization solvent are removed. The devolatilization step includes a vacuum devolatilization tank with a heater and the like. The devolatilization step may be performed, for example, by continuously taking out the solution containing the polymer from the reactor and introducing it into a vacuum devolatilization tank with preheaters configured in two stages in series. In the first devolatilization tank of the first stage, for example, the temperature can be set to 160 to 200°C and the pressure to 0.8 to 1.2 kPa. In the second devolatilization tank of the second stage, for example, the temperature can be set to 201 to 250°C and the pressure to 0.5 to 0.9 kPa. The molten polymer after the devolatilization step is transferred to the pelletizing step. In the pelletizing step, the molten resin is extruded into a strand form from a porous die and processed into a pellet form by a cold-cut method, an in-air hot-cut method, or an underwater hot-cut method. It is preferable not to perform devolatilization and addition of additives while kneading with an extruder in order to suppress the generation of dimerized or trimerized products (depolymerization due to thermal history).

[0058]

To the optical styrene-based resin composition, the hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenolic antioxidant (C-2) can be added to the styrene-based resin (A) as necessary. The hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenolic antioxidant (C-2) may be added to the raw material solution before the polymerization of the styrene-based resin (A), or may be mixed by a static mixing device after the polymerization of the styrene-based resin (A).

[0059]

The content of t-butylcatechol or 6-tert-butyl-2,4-xyleneol in the optical styrene-based resin composition can be adjusted by adjusting the content at the start of polymerization of the styrene-based resin (A) and by adjusting the content in the subsequent devolatilization step and the like.

[0060]

2. Molded Body and Light Guide Plate

The above optical styrene-based resin composition can be used for transmitting light from the LED light source having a maximum emission intensity in the wavelength region of 400 nm to 500 nm. A molded body according to an embodiment of the present invention is a molded body composed of the above optical styrene-based resin composition and can be obtained by molding the above optical styrene-based resin composition. A light guide plate according to an embodiment of the present invention is a light guide plate comprising the molded body composed of the above optical styrene-based resin composition and can be obtained by molding the above optical styrene-based resin

composition. The light guide plate is a light guide plate that can be used for an edge-light type planar light source unit.

[0061]

<Shape of Light Guide Plate>

The light guide plate may have a concave-convex shape on its surface. More precisely, the light guide plate may have a plurality of lenticular-shaped and/or prism-shaped convex parts on its surface. The convex part is preferably provided on at least one surface of the light guide plate, and particularly provided on one surface which is the front surface (light-emitting surface) of the light guide plate. The convex part may be provided on other surfaces, if necessary, but it is more preferable that they are provided only on the front surface (light-emitting surface) of the light guide plate.

[0062]

Here, the lenticular-shaped convex part is an arc-shaped convex part, and is a ridge body whose cross-sectional edge shape is an arc. The prism shape is a convex part, and is a ridge body whose cross-sectional edge shape is a triangular mountain shape. The convex parts may be formed in a plurality of rows so as to be parallel to each other. The convex parts may be integrally formed with the light guide plate.

[0063]

The thickness of the light guide plate is 0.2 to 3.0 mm, preferably 0.3 to 2.5 mm, and more preferably 0.4 to 2.4 mm. By setting the thickness of the light guide plate within such ranges, it is easy to produce a light guide plate having excellent moldability such as excellent extrusion stability and excellent strength in the molding of the optical styrene-based resin composition.

[0064]

<Optical Properties>

The average transmittance of the light guide plate at a wavelength of 380 to 780 nm with an optical path length of 115 mm is preferably 85% or more, and more preferably 86% or more.

[0065]

The YI value of the light guide plate with an optical path length of 115 mm is preferably 6.0 or less, and more preferably 4.0 or less.

[0066]

<Manufacturing Method of Light Guide Plate>

The light guide plate according to an embodiment of the present invention is obtained by molding the above optical styrene-based resin composition, and as a molding method, known methods such as sheet extrusion molding, injection molding, and compression molding can be used, but continuous sheet extrusion molding with a surface shape transfer mold is preferable in terms of productivity and ease of manufacturing large-sized molded products. Example of the sheet extrusion molding is a continuous sheet extrusion molding method having an extrusion step of supplying the

resin in a heated molten state to a feed block and continuously extruding it from a die to form a sheet, a pressing step of sandwiching the resin sheet with a pressure roll and a cooling roll, and a conveying step of conveying the resin sheet while keeping it in close contact with the cooling roll after the pressing step, wherein the surface of the cooling roll is provided with a transfer mold. By changing the shape of the transfer mold, an arbitrary concave-convex shape can be transferred to the sheet surface.

[0067]

The light guide plate may have a concave-convex shape on the front surface (light-emitting surface), and the back surface may be subjected to reflection processing to diffusely reflect light. Example of the reflection processing include silk printing, inkjet printing, and a method of forming dot-shaped concave-convex by laser irradiation. For printing the dot pattern, an ink containing fine particles for diffusing light can be used. That is, the light guide plate can include a light guide layer (light guide part) composed of the above optical styrene-based resin composition and a reflection processing layer (reflection processing part) for reflection.

[0068]

3. Edge-light Type Planar Light Source Unit

The edge-light type planar light source unit according to an embodiment of the present invention is an edge-light type planar light source unit having the above light guide plate and a light source that supplies LED light to an end face of the light guide plate. The edge-light type planar light source unit is suitably used as a planar light source device for a liquid crystal display device.

Example

[0069]

Hereinafter, the present invention will be described in more detail with reference to examples. These are merely illustrative and are not intended to limit the scope of the present invention.

[0070]

1. Manufacture of Optical Styrene-based Resin Composition

[Example 1]

The first reactor which was a complete stirred agitation tank and the second reactor which was a plug flow reactor with static mixer were connected in series to constitute a polymerization step, and the manufacture of the styrene-based resin (A) was performed. The capacity of each reactor was 30 liters for the first reactor and 12 liters for the second reactor. As shown in Table 1, for the raw material composition of 51 mass% of styrene, 39 mass% of methyl methacrylate, and 10 mass% of ethylbenzene, at the inlet of the first reactor, 150 ppm of t-butyl peroxyisopropyl monocarbonate (Perbutyl I, manufactured by NOF CORPORATION) as a polymerization initiator and 500 ppm of n-dodecyl mercaptan (manufactured by Arkema K.K.) as a chain transfer agent were adjusted to have

the addition concentrations (both are concentrations on a mass basis with respect to the raw material feed (total raw material monomers) [*1 in Table 1]), and then the raw material solution was continuously supplied to the first reactor set at 128°C at a rate of 8.0 kg/h. Furthermore, the obtained polymerization solution was continuously supplied to the second reactor to complete the polymerization. The monomer polymerization rate at this time was 70%. In the second reactor, a temperature gradient was applied along the flow direction, and the temperature was adjusted to 130°C in the middle part and 145°C at the outlet.

Subsequently, the solution containing the polymer continuously taken out from the second reactor was introduced into a vacuum devolatilization tank with preheaters configured in two stages in series, the temperature and pressure were adjusted as shown in Table 2, and unreacted monomers and ethylbenzene were separated. Various additives were melt-added to the obtained molten polymer to have the contents shown in Table 2, extruded in a strand form from a porous die via an SMX (static mixer), and the strands were cooled and cut by a cold-cut method to be pelletized.

[0071]

<Content of Monomer in Optical Styrene-based Resin Composition>

The amount of styrene-based monomer (styrene) in the styrene-based resin (A) was measured by accurately weighing 0.2 g of the styrene-based resin (A) sampled before melt-adding the various additives, dissolving it in 10 mL of tetrahydrofuran (THF) containing p-diethylbenzene as an internal standard substance, and measuring it under the following conditions using a capillary gas chromatograph. In the tables, the measurement results are shown as the content (μg) with respect to 1 g of the optical styrene-based resin composition.

Capillary gas chromatograph: GC-4000 (manufactured by GL Sciences Inc.)

Column: InertCap WAX, manufactured by GL Sciences Inc., inner diameter 0.25 mm, length 30 m, film thickness 0.50 μm

Injection temperature: 180°C

Column temperature: 60°C to 170°C

Detector temperature: 210°C

Split ratio: 5/1

[0072]

<Content of Dimer and Trimer in Optical Styrene-based Resin Composition>

The contents of the styrene-based linear dimer (2,4-diphenyl-1-butene) and the styrene-based linear trimer (2,4,6-triphenyl-1-hexene) of the styrene-based monomer (styrene) in the styrene-based resin (A) were measured under the following conditions and procedures.

- Sample preparation: 5 mL of THF was added to 0.1 g of the styrene-based resin (A), extracted by sonication, and then hexane was added to make the solution volume 50 mL to precipitate the polymer component. After standing, the supernatant liquid (total amount) was concentrated to 2

mL to obtain a measurement solution. In Tables 2 to 4, the measurement results are shown as the content (μg) with respect to 1 g of the optical styrene-based resin composition.

- Measurement conditions

Gas chromatograph: JEOL K9 (JEOL Ltd.)

Column: ZB-5MS 0.25 mm $\times$ 30 m, film thickness 0.25 μm

Injection temperature: 200°C

Column temperature: 40-320°C

Detector's temperature: 300°C

Split ratio: 10/1

Ionization method: EI

Mass range: $m/z = 29$ to 600

Carrier gas: Nitrogen

2,4-diphenyl-1-butene and 2,4,6-triphenyl-1-hexene were purchased from FUJIFILM Wako Pure Chemical Corporation, and calibration curves were prepared for quantification.

[0073]

<Melt Mass Flow Rate (MFR)>

The melt mass flow rate of the optical styrene-based resin composition was measured according to JIS K 7210 under the conditions of a temperature of 200°C and a load of 49 N.

[0074]

<Vicat Softening Temperature>

The Vicat softening temperature of the optical styrene-based resin composition was measured according to JIS K 7206 at a heating rate of 50°C/hour and a test load of 50 N.

[0075]

<Molecular Weight>

The weight average molecular weight (M_w) and number average molecular weight (M_n) of the styrene-based resin (A) were measured using gel permeation chromatography (GPC) under the following conditions.

GPC model: Shodex GPC-101, manufactured by Showa Denko K.K.

Column: PLgel 10 μm MIXED-B, manufactured by Polymer Laboratories Ltd.

Mobile phase: Tetrahydrofuran

Sample concentration: 0.2 mass%

Temperature: Oven 40°C, injection port 35°C, detector 35°C

Detector: Differential refractometer

The molecular weight was calculated as a polystyrene-equivalent molecular weight by calculating the molecular weight at each elution time from the elution curve of monodispersed polystyrene.

[0076]

Hereinafter, a plate-shaped test piece 1 was prepared as a molded body assuming a light guide plate, and the properties of the molded body were evaluated.

[0077]

<Evaluation of Optical Properties of Resin Composition>

Using the pellets of the obtained optical styrene-based resin composition, injection molding was performed at a cylinder temperature of 230°C and a mold temperature of 60°C. Using a mold polished so that the end face 3 is a mirror surface as shown in Figure 1, a molded body (plate-shaped test piece 1) of 115 mm × 80 mm × 3 mm (length × width × thickness) was molded (the surface opposite to each surface shown as end face 3 is also a mirror surface). Using an ultraviolet-visible spectrophotometer V-670 manufactured by JASCO Corporation, the spectral transmittance at a wavelength of 350 nm to 800 nm with an optical path length of 115 mm was measured with an incident light of size 20 × 1.6 mm and a divergence angle of 0°, and the YI value at a field of view of 2° under a C light source was calculated in accordance with JIS K7105. The average transmittance shown in Tables 2 to 4 indicates the average transmittance at a wavelength of 380 nm to 780 nm.

[0078]

<Dimensional Stability>

The plate-shaped test piece 1 was stored for 500 hours under the conditions of a temperature of 60°C and a relative humidity of 90%, the dimensional change of the long side before and after storage was measured, and the deformation rate was calculated by the following formula.

$$\text{Deformation rate} = ((\text{long side length after storage}) - (\text{long side length before storage})) / (\text{long side length before storage}) \times 100 (\%)$$

The dimensional stability (hygroscopic deformation) of the molded body was evaluated as "A" when the rate of change was less than 0.10%, as "B" when it was 0.10 to 0.15%, and as "C" when it was more than 0.15%.

[0079]

<Evaluation of Blue LD Durability of Resin Composition>

An irradiated part was set near the center of the surface 5 of the plate-shaped test piece 1, and an optical fiber (450±10 nm) of a PRESIZE GAUGE PLS-1000S was placed at a distance of 0.5 mm directly above the irradiated part, and the plate-shaped test piece 1 was irradiated with a blue LD at room temperature. The illuminance was measured using an illuminometer (sensor head H12684-385, controller C12144, manufactured by Hamamatsu Photonics K.K.), and the illuminance was 12 W/cm². Thereafter, the plate-shaped test piece 1 was taken out every 50 hours, the yellowness YI of the irradiated part was measured with a color-difference meter COLOR-7e2 (manufactured by Kurabo Industries Ltd.), and the time until the value exceeded 20 is shown in the tables. A case where the time until the yellowness YI exceeded 20 was more than 100 hours was considered acceptable.

[0080]

[Examples 2 to 22 and Comparative Examples 1 to 4]

Optical styrene-based resin compositions and molded bodies (plate-shaped test pieces 1) were produced in the same manner as in Example 1, except that the composition of the raw material solution and the polymerization conditions were changed as shown in Table 1, and the blending of the styrene-based resin (A), the hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenolic antioxidant (C-2) was changed as shown in Tables 2 to 4. The results of various measurements and evaluations are shown in Tables 2 to 4. "ND" in the tables indicates that no phosphorus atom was detected.

[0081]

[Table 1]

Table 1		Condition 1	Condition 2	Condition 3	Condition 4	Condition 5	Condition 6	Condition 7	Condition 8
Resin Name		A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8
Feed Flow Rate		kg/hr	kg/hr	kg/hr	kg/hr	kg/hr	kg/hr	kg/hr	kg/hr
Raw Material Composition	Styrene	51.0	65.5	79.0	27.0	51.0	51.0	51.0	51.0
	Methyl methacrylate	39.0	24.5	11.0	63.0	39.0	39.0	39.0	39.0
	Ethylbenzene	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
Polymerization Initiator		ppm *1	ppm *1	ppm *1	ppm *1	ppm *1	ppm *1	ppm *1	ppm *1
Chain Transfer Agent		ppm *1	ppm *1	ppm *1	ppm *1	ppm *1	ppm *1	ppm *1	ppm *1
Reaction Temperature	First Reactor	128	140	140	130	128	128	120	120
	Second Reactor (Middle)	130	130	140	130	130	130	130	130
	Second Reactor (Outlet)	145	150	165	145	145	145	140	140
First Devolatilization Tank	Resin Temperature	180	180	180	190	200	220	220	180
	Pressure	1.0	0.9	1.0	1.0	1.0	0.8	0.8	0.8
Second Devolatilization Tank	Resin Temperature	220	220	220	220	220	220	220	180
	Pressure	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.8

[0082]

[Table 2]

Table 2		Example										
		1	2	3	4	5	6	7	8	9	10	11
Formulation of Resin Composition	Styrene-based Resin (A)	–	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1
		mass%	47	47	47	47	47	47	47	47	47	47
	Hindered Amine Light Stabilizer (B)	parts by mass	100	100	100	100	100	100	100	100	100	100
		–	–	–	–	–	–	–	–	–	–	–
	Phosphorus-based Antioxidant (C-1)	parts by mass	–	–	–	–	–	–	–	–	–	–
		–	–	–	–	–	–	–	–	–	–	–
	Phenolic Antioxidant (C-2)	parts by mass	–	–	–	–	–	–	–	–	–	–
Properties of Resin Composition	Melt Mass Flow Rate	g/10min	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7	1.7
	Vicat Softening Temperature	°C	101	101	101	101	101	101	101	101	101	101
	Styrene-based Monomer (M)	μg/g	450	450	450	450	450	450	450	450	450	450
	Mw of Styrene-based Resin (A)	× 10 ⁴	17	17	17	17	17	17	17	17	17	17
	Mw/Mn of Styrene-based Resin (A)	–	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9	1.9
	Content of Styrene-based Linear Dimer (2,4-Diphenyl-1-butene) (D)	μg/g	30	30	30	30	30	30	30	30	30	30
	Content of Styrene-based Linear Trimer (2,4,6-Triphenyl-1-hexene) (T)	μg/g	170	170	170	170	170	170	170	170	170	170
	Content of Phosphorus Atom (P)	μg/g	ND	11	48	98	ND	11	27	10	20	98
	(M+D+T) × P	–	–	7150	31200	63700	–	7150	17550	6500	13000	63700
	Optical Properties with Optical Path Length of 115 mm	Average Transmittance Y1 Value	89	89	89	88	88	89	88	88	88	89
Properties of Molded Body	Dimensional Stability (Hygroscopic Deformation)	–	1.8	1.7	1.5	2.0	2.0	1.9	1.5	1.9	2.1	1.4
		–	A	A	A	A	A	A	A	A	A	A
	LD Durability	hour	600	550	250	150	1000	1000	850	1000	400	450

[0083]

[Table 3]

Table 3			Example																
			12	13	14	15	16	17	18	19	20	21	22						
Formulation of Resin Composition	Styrene-based Resin (A)	Type	A-1	A-2	A-2	A-3	A-4	A-4	A-5	A-5	A-1	A-1							
		Content of MMA Unit	47	32	32	15	70	70	47	47	47	47	47						
		Amount Added	100	100	100	100	100	100	100	100	100	100	100						
	Hindered Amine Light Stabilizer (B)	Type	292	–	292	292	–	292	–	292	292	292	944						
		Amount Added	0.1	–	0.1	0.1	–	0.1	–	0.1	0.05	0.7	0.1						
		Type	HP-10	–	–	–	–	–	–	–	–	–	–						
	Antioxidant (C)	Phosphorus-based Antioxidant (C-1)	0.02	–	–	–	–	–	–	–	–	–	–						
		Phenolic Antioxidant (C-2)	1076	–	–	–	–	–	–	–	–	–	–						
		Amount Added	0.05	–	–	–	–	–	–	–	–	–	–						
	Properties of Resin Composition	Melt Mass Flow Rate		1.7	2.6	2.7	3.4	1.5	1.5	1.7	1.7	1.7	1.7						
Vicat Softening Temperature		101	99	99	100	103	103	101	101	101	101								
Styrene-based Monomer (M)		450	600	600	700	400	400	700	700	450	450								
Mw of Styrene-based Resin (A)		17	18	18	21	11	11	17	17	17	17								
Mw/Mn of Styrene-based Resin (A)		1.9	2.0	2.0	2.2	2.1	2.1	2.0	2.0	1.9	1.9								
Content of Styrene-based Linear Dimer (2,4-Diphenyl-1-butene) (D)		30	50	50	70	15	15	50	50	30	30								
Content of Styrene-based Linear Trimer (2,4,6-Triphenyl-1-hexene) (T)		170	280	280	350	100	100	300	300	170	170								
Content of Phosphorus Atom (P)		11	ND	ND	ND	ND	ND	ND	ND	ND	ND								
(M+D+T) × P		7150																	
Properties of Molded Body		Optical Properties with Optical Path Length of 115 mm	Average Transmittance Y1 Value	90	87	87	87	90	90	89	88	88	88						
	Dimensional Stability (Hygroscopic Deformation)	–	2.0	2.2	2.4	2.7	1.4	1.5	1.9	2.0	2.5	2.5							
	LD Durability	–	A	A	A	A	B	B	A	A	A	A							
	Yellowing Time	hour	800	550	950	700	700	1000	550	900	1000	1000							

[0084]

[Table 4]

Table 4					Comparative Example			
					1	2	3	4
Formulation of Resin Composition	Styrene-based Resin (A)		Type	—	A-6	A-6	A-7	A-8
			Content of MMA Unit	mass%	47	47	47	47
			Amount Added	parts by mass	100	100	100	100
	Hindered Amine Light Stabilizer (B)		Type	—	—	—	—	—
			Amount Added	parts by mass	—	—	—	—
	Antioxidant (C)	Phosphorus-based Antioxidant (C-1)	Type	—	—	168	—	—
			Amount Added	parts by mass	—	0.2	—	—
		Phenolic Antioxidant (C-2)	Type	—	—	—	—	—
			Amount Added	parts by mass	—	—	—	—
Properties of Resin Composition	Melt Mass Flow Rate			g/10min	1.7	1.7	1.7	1.7
	Vicat Softening Temperature			°C	101	101	101	101
	Styrene-based Monomer (M)			μ g/g	370	370	450	1500
	Mw of Styrene-based Resin (A)			× 10 ⁴	17	17	17	17
	Mw/Mn of Styrene-based Resin (A)			—	1.9	1.9	2.0	2.1
	Content of Styrene-based Linear Dimer (2,4-Diphenyl-1-butene) (D)			μ g/g	130	130	200	80
	Content of Styrene-based Linear Trimer (2,4,6-Triphenyl-1-hexene) (T)			μ g/g	780	780	980	380
	Content of Phosphorus Atom (P)			μ g/g	—	100	—	—
	(M+D+T) × P			—		128000		
Properties of Molded Body	Optical Properties with Optical Path Length of 115 mm		Average Transmittance	%	87	87	87	88
			YI Value	—	2.3	2.3	2.1	1.9
	Dimensional Stability (Hygroscopic Deformation)		—	A	A	A	A	
	LD Durability		Yellowing Time	hour	100	50	50	50

[0085]

The hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenolic antioxidant (C-2) in Tables 2 to 4 are as follows, respectively.

[0086]

(Hindered Amine Light Stabilizer (B))

944: Polycondensate of 2,4-dichloro-6-(1,1,3,3-tetramethylbutylamino)-1,3,5-triazine and N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine (Chimassorb 944FDL, manufactured by BASF)

292: Mixture of methyl (1,2,2,6,6-pentamethylpiperidin-4-yl) sebacate (25%) and bis(1,2,2,6,6-pentamethylpiperidin-4-yl) sebacate (75%) (TINUVIN 292, manufactured by BASF)

[0087]

(Phosphorus-based Antioxidant (C-1))

168: Tris(2,4-di-tert-butylphenyl) phosphite (Irgafos 168, manufactured by BASF)

HP-10: 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy)(2-ethylhexyloxy)phosphorous (ADK STAB HP-10, manufactured by ADEKA)

PEP-36: 3,9-bis(2,6-di-tert-butyl-4-methylphenoxy)-2,4,8,10-tetraoxa-3,9-diphosphaspiro[5.5]undecane (ADK STAB PEP-36, manufactured by ADEKA Corporation)

[0088]

(Phenolic Antioxidant (C-2))

1076: Octadecyl-3-(3,5-di-t-butyl-4-hydroxyphenyl)propionate (Irganox 1076, manufactured by BASF)

[0089]

In Examples 1 to 22, the transparency (average transmittance), hue (YI value), and dimensional stability were good, and the LD durability was excellent.

Reference Signs List

[0090]

1: Molded body

3: End face (mirror surface)

5: Surface

CLAIMS

[Claim 1]

An optical styrene-based resin composition comprising a styrene-based resin, wherein with respect to 1 g of the optical styrene-based resin composition:

a content of a styrene-based monomer is 1000 μg or less; and

a total content of a styrene-based monomer linear dimer and a styrene-based monomer linear trimer is 10 to 500 μg .

[Claim 2]

The optical styrene-based resin composition of Claim 1, wherein the styrene-based resin is a copolymer comprising 95 to 20 mass% of a styrene-based monomer unit and 5 to 80 mass% of a (meth)acrylic acid ester-based monomer unit.

[Claim 3]

The optical styrene-based resin composition of Claim 1, wherein a content of a phosphorus atom is 50 μg or less with respect to 1 g of the optical styrene-based resin composition.

[Claim 4]

The optical styrene-based resin composition of Claim 1, satisfying a following formula (1), wherein M (μg) is the content of the styrene-based monomer, D (μg) is a content of the styrene-based monomer linear dimer, T (μg) is a content of the styrene-based monomer linear trimer, and P (μg) is a content of a phosphorus atom, with respect to 1 g of the optical styrene-based resin composition.

$$(M + D + T) \times P \leq 20000 \quad (1)$$

[Claim 5]

The optical styrene-based resin composition of Claim 1, comprising 0.001 to 0.5 parts by mass of a hindered amine light stabilizer with respect to 100 parts by mass of the styrene-based resin.

[Claim 6]

The optical styrene-based resin composition of Claim 1, for use in transmitting light from an LED light source having a maximum emission intensity in a wavelength region of 400 nm to 500 nm.

[Claim 7]

A molded body composed of the optical styrene-based resin composition of any one of Claims 1 to 6.

[Claim 8]

A light guide plate comprising the molded body of Claim 7.

[Claim 9]

An edge-light type planar light source unit, comprising the light guide plate of Claim 8, and a light source which supplies LED light to an end face of the light guide plate.