

DESCRIPTION

Title of Invention:

OPTICAL STYRENE-BASED RESIN COMPOSITION, LIGHTGUIDE PLATE, EDGE-LIGHT SYSTEM FLAT-SURFACE LIGHT SOURCE UNIT, LIGHT DIFFUSION PLATE, AND DIRECT UNDER-LIGHT SYSTEM FLAT-SURFACE LIGHT SOURCE UNIT

Technical Field

[0001]

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

Background Art

[0002]

There are two types of backlights for liquid crystal displays: a direct-light type backlight, in which the light source is placed in front of the display unit, and an edge-light type backlight, in which the light source is placed on the side of the display unit. A component called light guide plate is used in the edge-light type backlight to guide the light from the light source placed at the side of the edge-light type backlight to the front of the display device. The edge-light type backlights are used in a wide range of applications such as televisions, desktop personal computer monitors, laptop personal computers, cellular phones, and car navigation monitors. Backlights using the light guide plate are also used as lighting devices and signs.

[0003]

Since light guide plates require relatively long light transmission distance, loss of light in the optical path length becomes large. Therefore, particularly high light transmittance is required for the light guide plates. For this reason, acryl-based resin such as polymethyl methacrylate (PMMA) is used as the material of the light guide plates. However, since PMMA has high water absorbency, the light guide plate can undergo warpage and dimensional variation due to water absorption. Further, since PMMA is prone to undergo thermal decomposition during molding, the appearance of the molded body tends to degrade when molding is performed at high temperature. To solve such problems, the use of styrene-methyl (meth)acrylate copolymer as the material of the light guide plates is proposed in Patent Literature 1, for example.

[0004]

On the other hand, the molded body of styrene-methyl (meth)acrylate copolymer has a poor hue compared to 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

[Patent Literature 2] WO2016/129675

Summary of Invention

Technical Problem

[0006]

In recent years, with the increasing resolution of backlight units for televisions, monitors, and the like, high-brightness LEDs are sometimes used as an edge light source. However, in conventional light guide plates made of styrene-methyl (meth)acrylate copolymer, deterioration (carbonization) sometimes occurred at the edge surfaces of the light guide plate after being turned on for a long period of time, depending on the usage environment.

[0007]

The present invention has been made in view of such circumstances, and aims to provide an optical styrene-based resin composition having excellent transparency, hue, and dimensional stability, and having excellent light stability for long-term use of a LED light source.

Solution to Problem

[0008]

According to the present invention, provided is an optical styrene-based resin composition, containing a styrene-based resin (A) and a hindered amine light stabilizer (B), in which: the styrene-based resin (A) is a copolymer containing a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit; the copolymer contains 95 to 20 mass% of the styrene-based monomer unit and 5 to 80 mass% of the (meth)acrylic acid ester-based monomer unit in 100 mass% of the copolymer; and the optical styrene-based resin composition contains 0.001 to 1.0 parts by mass of the hindered amine light stabilizer (B) with respect to 100 parts by mass of the styrene-based resin (A).

[0009]

The inventors have conducted extensive studies and have found that an optical styrene-based resin composition containing a styrene-based resin with the contents of a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit within specific ranges and a hindered amine light stabilizer whose content is within a specific range simultaneously satisfies transparency, hue, dimensional stability, and light stability for long-term use

of an LED light source, thereby leading to the completion of the present invention.

[0010]

Hereinafter, various embodiments of the present invention will be exemplified. The embodiments shown below can be combined with each other.

[1] An optical styrene-based resin composition, containing a styrene-based resin (A) and a hindered amine light stabilizer (B), in which:

the styrene-based resin (A) is a copolymer containing a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit;

the copolymer contains 95 to 20 mass% of the styrene-based monomer unit and 5 to 80 mass% of the (meth)acrylic acid ester-based monomer unit in 100 mass% of the copolymer; and

the optical styrene-based resin composition contains 0.001 to 1.0 parts by mass of the hindered amine light stabilizer (B) with respect to 100 parts by mass of the styrene-based resin (A).

[2] The optical styrene-based resin composition of [1], in which the hindered amine light stabilizer (B) is an N-H type hindered amine light stabilizer and/or an N-R type hindered amine light stabilizer.

[3] The optical styrene-based resin composition of [2], in which the N-H type hindered amine light stabilizer is at least one selected from a group consisting of: bis(2,2,6,6-tetramethylpiperidin-4-yl)sebacate; 2,2,6,6-tetramethyl-4-piperidyl hexadecanoate; 2,2,6,6-tetramethyl-4-piperidyl octadecanoate; tetrakis(2,2,6,6-tetramethyl-4-piperidyl)-1,2,3,4-butanetetracarboxylate; polycondensate of N,N'-bis(2,2,6,6-tetramethylpiperidin-4-yl)hexamethylenediamine and 4-morpholino 2,6-dichloro-1,3,5-triazine; polycondensate of 2,4-dichloro-6-(1,1,3,3-tetramethylbutylamino) and 1,3,5-triazine/N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine; 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-piperidinamine; 1,6,11-tris[2,4-bis(N-butyl-N-(2,2,6,6-tetramethyl-4-piperidyl)amino)-s-triazin-6-yl]aminoundecane; and 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.

[4] The optical styrene-based resin composition of [2] or [3], in which the N-R type hindered amine light stabilizer is at least one selected from a group consisting of: methyl(1,2,2,6,6-pentamethylpiperidin-4-yl)sebacate; bis(1,2,2,6,6-pentamethylpiperidin-4-yl)sebacate; bis(1,2,2,6,6-pentamethylpiperidin-4-yl) n-butyl 3,5-di-tert-butyl 4-

hydroxybenzyl malonate; polycondensate of 4-hydroxy-2,2,6,6-tetramethyl-1-piperidineethanol and dimethyl succinate; 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; 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; and a mixture of polycondensate of succinic acid and (4-hydroxy-2,2,6,6-tetramethylpiperidin-1-yl)ethanol with 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.

[5] The optical styrene-based resin composition of any one of [1] to [4], containing 0.001 to 0.5 parts by mass of a phosphorus-based antioxidant (C-1) with respect to 100 parts by mass of the styrene-based resin (A).

[6] The optical styrene-based resin composition of [5], in which the phosphorus-based antioxidant (C-1) is at least one selected from a group consisting of: tris(2,4-di-tert-butylphenyl) phosphite; 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy) (2-ethylhexyloxy) phosphorus; bis-(2,4-di-tert-butylphenyl)pentaerythritol diphosphate; 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; and bis(2,4-di-tert-butyl-6-methylphenyl)ethyl phosphite.

[7] A light guide plate obtained by molding the optical styrene-based resin composition of any one of [1] to [6].

[8] An edge-light type planer light source unit, having the light guide plate of [7] and a light source which supplies LED light to an end surface of the light guide plate.

[9] A light diffusion plate obtained by molding the optical styrene-based resin composition of any one of [1] to [6].

[10] A direct-light type planer light source unit, having the light diffusion plate of [9] and a light source which supplies LED light to the light diffusion plate.

Description of Embodiments

[0011]

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

[0012]

1. Optical Styrene-based Resin Composition

The optical styrene-based resin composition of one embodiment of the present invention is an optical styrene-based resin

composition containing a styrene-based resin (A) and a hindered amine light stabilizer (B).

[0013]

<Styrene-based Resin (A)>

The styrene-based resin (A) is 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 a copolymer containing a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit. The copolymer contains 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 contains 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 contains 80 to 30 mass% of the styrene-based monomer unit and 20 to 70 mass% of the (meth)acrylic acid ester-based monomer unit, end even more preferably contains 60 to 40 mass% of the styrene-based monomer unit and 40 to 60 mass% of the (meth)acrylic acid ester-based monomer unit, in 100 mass% of the copolymer. When the contents of the monomer units are within such ranges, transparency, hue, and dimensional stability are simultaneously satisfied. By setting the content of the styrene-based monomer unit to 90 mass% or less, a light guide plate having excellent transparency and hue can be obtained. By setting the content of the styrene-based monomer unit to 20 mass% or more, a light guide plate having excellent dimensional stability can be obtained. The content of the (meth)acrylic acid ester-based monomer unit in the styrene-based resin (A) is, specifically 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 in the range between the two values exemplified herein.

[0014]

Examples of the styrene-based monomer include styrene, α -methyl styrene, o-methyl styrene, p-methyl styrene, m-methyl styrene, ethyl styrene, and p-t-butyl styrene. These styrene-based monomers can be used alone, or two or more types of these can be used in combination. The styrene-based monomer is preferably styrene.

[0015]

Examples of the (meth)acrylic acid ester-based monomer include (meth)acrylic acid alkyl esters 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; (meth)acrylic acid aryl esters such as phenyl (meth)acrylate and benzyl (meth)acrylate; (meth)acrylic acid cycloalkyl esters such as cyclohexyl (meth)acrylate, 4-t-butyl cyclohexyl (meth)acrylate,

2-norbornyl (meth)acrylate, isobornyl (meth)acrylate, adamantan-1-yl (meth)acrylate, 2-methyladamantan-2-yl (meth)acrylate, 2-ethyl-2-adamantyl (meth)acrylate, and tricyclodecanyl (meth)acrylate; glycidyl (meth)acrylate; and dicyclopentanyl (meth)acrylate. These (meth)acrylic acid ester-based monomers can be used alone, or two or more types of these can be used in combination. The (meth)acrylic acid ester-based monomer is preferably (meth)acrylic acid alkyl ester, and more preferably methyl methacrylate.

[0016]

Further, the styrene-based resin (A) may be a copolymer obtained by copolymerizing the styrene-based monomer and the (meth)acrylic acid ester-based monomer with a monomer copolymerizable therewith. Examples of the copolymerizable monomer include (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 anhydride; and imides such as phenyl maleimide and cyclohexyl maleimide. These copolymerizable monomers can be used alone, or two or more types of these can be used in combination.

[0017]

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 1.0 to 3.5, and more preferably 1.5 to 3.0. When the weight average molecular weight (M_w) and the ratio (M_w/M_n) are within such ranges, both of the molding property 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 article becomes insufficient, and when the weight average molecular weight (M_w) exceeds 400,000, the molding property may deteriorate. Further, when the ratio (M_w/M_n) of the weight average molecular weight (M_w) to the number average molecular weight (M_n) is less than 1.0, the molding property deteriorates, and when the ratio (M_w/M_n) exceeds 3.5, the strength of the molded article may be insufficient.

[0018]

<Hindered Amine Light Stabilizer (B)>

The optical styrene-based resin composition contains 0.001 to 1.0 parts by mass of the hindered amine light stabilizer (B) with respect to 100 parts by mass of the styrene-based resin (A), and preferably contains 0.01 to 0.3 parts by mass. By setting the content of the hindered amine light stabilizer (B) within such a range, transparency, hue, and light stability for a LED light source can be improved. The content of the hindered amine light stabilizer (B) with respect to 100 parts by mass of the styrene-

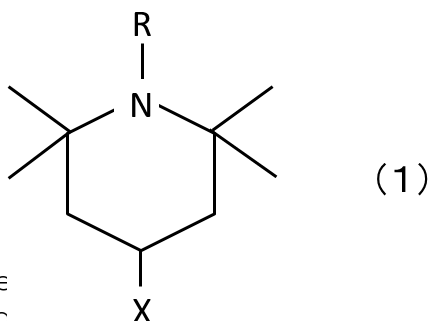
based resin (A) is, specifically for example, 0.001, 0.005, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, or 1.0 parts by mass, and may be in the range between the two values exemplified herein. One of the hindered amine light stabilizers (B) may be used alone, or two or more types of the hindered amine light stabilizers (B) may be used in combination.

[0019]

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

[0020]

[Chem. 1]



[0021]

In general, R is an organic group bonded to the 1-position carbon atom, oxygen atom, or nitrogen atom, and examples of R include a hydrogen atom, a linear alkyl group having 1 to 10 carbon atoms, a branched alkyl group, a methylene group, and an alkoxy group. Here, the compound is taken as an N-H type hindered amine light stabilizer when R is a hydrogen atom, taken as an N-R type hindered amine light stabilizer when R is a linear alkyl group having 1 to 10 carbon atoms, a branched alkyl group, or a methylene group, and taken as an N-OR hindered amine type light stabilizer when R is an alkoxy group.

[0022]

Specific examples of the N-H type hindered amine light stabilizer include bis(2,2,6,6-tetramethylpiperidin-4-yl)sebacate (TINUVIN770DF made by BASF), 2,2,6,6-tetramethyl-4-piperidyl hexadecanoate, 2,2,6,6-tetramethyl-4-piperidyl octadecanoate (SABOSTAB UV91 made by SONGWON), tetrakis(2,2,6,6-tetramethyl-4-piperidyl)-1,2,3,4-butanetetracarboxylate (ADK STAB LA-57 made by ADEKA), 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 made by SONGWON), polycondensate of 2,4-dichloro-6-(1,1,3,3-tetramethylbutylamino) 1,3,5-triazine/N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine (Chimassorb944FDL made by BASF), 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-piperidinamine (SABOSTAB UV40 made 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 (Chimassorb2020FDL made by BASF), 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 (ADKSTAB LA-68 made 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 made by CLARIANT), and polycondensate of 2,2,4,4-tetramethyl-7-oxa-3,20-diazadispiro-(5.1.11.2)henicosan-21-one and epichlorohydrin (HOSTAVIN N30P made by CLARIANT).
[0023]

Specific 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, made by BASF), bis(1,2,2,6,6-pentamethylpiperidin-4-yl) n-butyl 3,5-di-tert-butyl 4-hydroxybenzyl malonate (TINUVIN144 made by BASF), polycondensate of 4-hydroxy-2,2,6,6-tetramethyl-1-piperidineethanol and dimethyl succinate (TINUVIN622SF made 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 made by BASF), 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 (ADKSTAB LA-63P made by ADEKA), and a mixture of polycondensate of succinic acid and (4-hydroxy-2,2,6,6-tetramethylpiperidin-1-yl)ethanol with 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 (TINUVIN111FDL made by BASF).
[0024]

Specific examples of the N-OR type hindered amine light stabilizer include bis(1-octyloxy-2,2,6,6-tetramethylpiperidyl)sebacate (TINUVIN123 made by BASF), and bis(1-undecanoxy-2,2,6,6-tetramethylpiperidin-4-yl)carbonate (ADKSTAB LA-81 made by ADEKA).
[0025]

Among these, the hindered amine light stabilizer (B) is preferably the N-H type hindered amine light stabilizer and/or the N-R type hindered amine light stabilizer, and more preferably the N-R type hindered amine light stabilizer, in that it has little effect on the transparency and hue of the optical styrene-based resin composition. It is generally known that the hindered amine

light stabilizer (B) is oxidized by oxygen, ultraviolet rays, and peroxide to generate nitroxy radicals. In the present embodiment, although the mechanism by which the hindered amine light stabilizer (B) can improve the light stability for long-term use of a LED light source is still under investigation, the effectiveness of the hindered amine light stabilizer (B) has been discovered by the present invention.

[0026]

<Antioxidant (C)>

The optical styrene-based resin composition preferably contains 0.001 to 0.5 parts by mass of a phosphorus-based antioxidant (C-1) with respect to 100 parts by mass of the styrene-based resin (A), more preferably 0.002 to 0.4 parts by mass, and even more preferably 0.005 to 0.3 parts by mass. By setting the content of the phosphorus-based antioxidant (C-1) within such a range, the transparency and hue can be improved. The content of the phosphorus-based antioxidant (C-1) is, specifically for example, 0.001, 0.002, 0.003, 0.004, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.3, 0.4, or 0.5 parts by mass with respect to 100 parts by mass of the styrene-based resin (A), and may be in the range between the two values exemplified herein.

[0027]

The phosphorus-based antioxidant (C-1) is a phosphorous/phosphate ester which does not have a phenolic hydroxyl group within its basic skeleton, and is preferably a phosphorous ester which is a trivalent phosphorus compound. Specific examples of the phosphorus-based antioxidant (C-1) include 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy) (2-ethylhexyloxy) phosphorus, bis-(2,4-di-tert-butylphenyl)pentaerythritol diphosphate, 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, and bis(2,4-di-tert-butyl-6-methylphenyl)ethyl phosphite. These phosphorus-based antioxidants can be used alone, or two or more types of these can be used in combination.

[0028]

Further, the optical styrene-based resin composition may contain 0 to 0.5 parts by mass of a phenol-based antioxidant (C-2) with respect to 100 parts by mass of the styrene-based resin (A). The hue deteriorates if the content of the phenol-based antioxidant (C-2) exceeds 0.5 parts by mass, which is not preferable. The content of the phenol-based antioxidant (C-2) is, specifically for example, 0, 0.001, 0.002, 0.003, 0.004, 0.005, 0.01, 0.02, 0.05, 0.1, 0.2, 0.3, 0.4, or 0.5 parts by mass with respect to 100 parts by mass of the styrene-based resin (A), and

may be in the range between the two values exemplified herein.
[0029]

The phenol-based antioxidant (C-2) is an antioxidant which has a phenolic hydroxyl group within its basic skeleton and is not a phosphorous/phosphate ester. Specific examples of the phenol-based antioxidant (C-2) include octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate, ethylene bis(oxyethylene) bis[3-(5-tert-butyl-4-hydroxy-m-tolyl)propionate], and pentaerythritol tetrakis [3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate]. These phenol-based antioxidants can be used alone, or two or more types of these can be used in combination.

[0030]

The antioxidant includes phosphorus-phenol-based 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]dioxaphosphine. In the case of such a compound, the optical styrene-based resin composition is considered to contain both the phosphorus-based antioxidant and the phenol-based antioxidant. For example, when the optical styrene-based resin composition contains 0.1 parts by mass of the phosphorus-phenol-based compound with respect to 100 parts by mass of the styrene-based resin (A), the optical styrene-based resin composition is considered to contain 0.1 parts by mass of the phosphorus-based antioxidant and 0.1 parts by mass of the phenol-based antioxidant.

[0031]

<Other Component>

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. When the content of TBC is within such a range, a light guide plate having excellent hue and transmittance can be obtained. The content of TBC is, specifically 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 in the range between the two values exemplified herein.

[0032]

The content of 6-tert-butyl-2,4-xyleneol (TBX) in the optical styrene-based resin composition is preferably 10 ppm or less, and more preferably 5 ppm or less. When the content is within such a range, a light guide plate having excellent hue and transmittance can be obtained. The content of TBX is, specifically 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, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, or 20 ppm, and may be in the range between the two values exemplified herein.

[0033]

The optical styrene-based resin composition can contain

sulfur-based antioxidants; lactone-based antioxidants; UV absorbers; antistatic agents; hydrophilic additives; bluing agents; and mold release agents such as liquid paraffins (mineral oils), polyethylene wax, microcrystalline wax, higher fatty acids such as lauric acid, myristic acid, palmitic acid, and stearic acid, higher fatty acid amides such as stearic acid amide, erucic acid amide, and ethylene bis-stearic acid amide, higher fatty acid glycerides such as lauric acid monoglyceride, palmitic acid monoglyceride, stearic acid monoglyceride, and behenic acid monoglyceride, higher alcohols such as myristyl alcohol, cetyl alcohol, and stearyl alcohol; so long as it does not impair the characteristics of the present invention.

[0034]

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. If the MFR is less than 0.5 g/10 min, molding stability decreases, and if the MFR exceeds 5.0 g/10 min, strength becomes insufficient.

[0035]

The Vicat softening temperature of the optical styrene-based resin composition is preferably 95 to 104°C, and more preferably 100 to 104°C. If 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.

[0036]

<Manufacturing Method of Styrene-based Resin Composition>

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

[0037]

In the polymerization of the styrene-based resin (A), polymerization auxiliary agents such as polymerization initiators, chain transfer agents, crosslinking agents, and other polymerization auxiliary agents can be used as necessary. As the polymerization initiator, radical polymerization initiator is preferable. Examples of the known radical polymerization initiator include peroxyketals such as 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 peroxyisononanoate; dialkyl peroxides such as t-butyl cumyl peroxide, di-t-butyl peroxide, dicumyl peroxide, and di-t-hexyl peroxide; peroxy esters such as t-butyl peroxyacetate, t-butyl peroxy benzoyate, and t-butyl peroxy isopropyl monocarbonate; peroxycarbonates such as t-butyl peroxy isopropyl carbonate and polyether tetrakis(t-butyl peroxycarbonate); N,N'-azobis(cyclohexane-1-carbonitrile); N,N'-azobis(2-methylbutyronitrile); N,N'-azobis(2,4-dimethylvaleronitrile); and N,N'-azobis[2-(hydroxymethyl)propionitrile]. These polymerization initiators can be used alone, or two or more types of these can be used in combination. Examples of the chain transfer agent include 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 esterification of hydroxyl groups of polyhydric alcohols such as ethylene glycol, tetraethylene glycol, neopentyl glycol, trimethylol propane, pentaerythritol, dipentaerythritol, tripentaerythritol, and sorbitol with thioglycolic acid or mercaptopropionic acid; pentaphenyl ethane; α -methylstyrene dimer; and terpinolene. Among these, aliphatic mercaptans, aromatic mercaptans, thiocarboxylic acids, and polyfunctional mercaptans are preferable in terms of easiness of molecular weight adjustment.

[0038]

When continuous polymerization is performed, the styrene-based resin (A) can be manufactured by a method including a polymerization step, a devolatilization step, and a pelletizing step.

[0039]

First, in the polymerization step, a conventional complete stirred tank-type agitation tank or column reactor is used. The polymerization reaction is controlled by adjusting the polymerization temperature and the like to achieve target molecular weight, molecular weight distribution, and reaction conversion rate.

[0040]

The polymerization solution containing the polymer after the polymerization step is transferred to the devolatilization step, and the unreacted monomers and the polymerization solvent are removed. The devolatilization step includes a vacuum devolatilization tank equipped with a heater, a devolatilizing extruder equipped with a vent, and the like. The molten polymer after the devolatilization step is transferred to the pelletizing step. In the pelletizing step, the molten resin is extruded into strands from a porous die, and processed into pellets by cold

cutting method, air-cooled hot cutting method, or underwater hot cutting method.

[0041]

The optical styrene-based resin composition can be manufactured by adding the hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenol-based antioxidant (C-2) to the styrene-based resin (A). The hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenol-based antioxidant (C-2) may be added to the raw material solution before polymerization of the styrene-based resin (A), or may be mixed in an extruder or static mixer installed after polymerization of the styrene-based resin (A) and before pelletization. Further, the optical styrene-based resin composition may be manufactured by dry-blending and melt-kneading the styrene-based resin (A) with the pellets after pelletization, the hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenol-based antioxidant (C-2). Further, the hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), and the phenol-based antioxidant (C-2) may be melt-kneaded in advance with a small amount of the styrene-based resin to prepare a pellet-shaped master batch, and the master batch may then be dry-blended with the styrene-based resin (A) and melt-kneaded for adjustment.

[0042]

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 when the polymerization of the styrene-based resin (A) is initiated, and by adjusting the content during the devolatilization step and the like thereafter.

[0043]

2. Light Guide Plate

The light guide plate of one embodiment of the present invention is a molded article obtained by molding the above-mentioned optical styrene-based resin composition. The light guide plate can be used for the edge-light type planar light source unit.

[0044]

<Shape of Light Guide Plate>

The light guide plate may have a concave-convex shape at the surface of the light guide plate. More precisely, the surface of the light guide plate can be provided with a plurality of convex portions in a lenticular shape and/or a prism shape. The convex portion is preferably provided on at least one surface of the light guide plate, and is particularly provided on one surface which is the front surface (light emitting surface) of the light guide plate. The convex portion may be provided on other surfaces if necessary. However, it is more preferable to provide the convex portion only on the front surface (light emitting surface) of the

light guide plate.

[0045]

Here, the convex portion in a lenticular shape is an arc-shaped convex portion and is a protrusion streak, with the edge of the cross section forming an arc-shape. The convex portion in a prism shape is an arc-shaped convex portion and is a protrusion streak, with the edge of the cross section forming a triangular mountain-shape. Further, the convex portion may be formed so that the plurality of streaks would be parallel with each other. The convex portion may be formed integrally with the light guide plate.

[0046]

The thickness of the light guide plate is 0.2 to 3.0 mm, more preferably 0.3 to 2.5 mm, and even more preferably 0.4 to 2.4 mm. When the thickness is within such a range, a light guide plate having excellent strength and molding property such as extrusion stability can be easily manufactured in molding the optical styrene-based resin composition.

[0047]

<Optical Characteristic>

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

[0048]

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

[0049]

<Manufacturing Method of Light Guide Plate>

The light guide plate of one embodiment of the present invention is obtained by molding the above-mentioned optical styrene-based resin composition. As the molding method, known methods such as sheet extrusion molding, injection molding, and compression molding can be used. In terms of productivity and the ease of enlarging the molded article, continuous sheet extrusion molding provided with a surface shape transfer mold is preferable. Example of the sheet extrusion molding include a continuous sheet extrusion molding method, including an extrusion step to supply the heat-molten resin to a feed block and to form an extruded sheet continuously from a die; a pressing step to pinch the resin sheet with a pressing roll and a cooling roll; and a transferring step performed after the pressing step to transfer the resin sheet while allowing the resin sheet to be adhered to the cooling roll, in which the surface of the cooling roll is provided with a transfer mold. By altering the shape of the transfer mold, an arbitrary concave-convex shape can be transferred onto the surface of sheet.

[0050]

Further, the light guide plate may be provided with a concave-

convex shape on the front surface (light emitting surface) thereof, and the rear surface may be subjected to a reflection processing to diffuse the light. Examples of the reflection processing include silk printing and inkjet printing, as well as laser irradiation to provide dot-shaped roughness. An ink having fine particles which can diffuse light can be used for printing of a dot pattern.

[0051]

3. Edge-light Type Planar Light Source Unit

The edge-light type planar light source unit of one embodiment of the present invention is an edge-light type planar light source unit having the above-mentioned light guide plate and a light source which supplies LED light to an end surface of the light guide plate. The edge-light type planar light source unit is suitably used as a planar light source device for liquid crystal displays.

[0052]

4. Light Diffusion Plate

The light diffusion plate of one embodiment of the present invention is a molded article obtained by molding the optical styrene-based resin composition. The light diffusion plate can be used for a direct-light type planer light source unit.

[0053]

<Shape of Light Diffusion Plate>

The thickness of the light diffusion plate of one embodiment of the present invention is not limited, and is, for example, 1 to 3 mm. The surface of the light diffusion plate may be coated with an antistatic agent. The coating with an antistatic agent suppresses the adhesion of dust and the like due to static electricity after the light diffusion plate is attached to the backlight device, allowing the light diffusion plate to be used for a long period of time without decrease in brightness. Further, the light diffusion plate of the present invention may have a fine concave-convex shape such as emboss processing on both sides or on one side thereof, and may have a lenticular or prism shape on both sides or on one side thereof.

[0054]

The light diffusion plate may contain 0.1 to 1.0 parts by mass of a light diffusing agent with respect to 100 parts by mass of the optical styrene-based resin composition. The light diffusing agent can be used if it is a particle having a different refractive index from the optical styrene-based resin composition and having the effect of diffusing incident light. For example, organic particles such as styrene-based polymer particles, acrylic polymer particles, and siloxane-based polymer particles, and inorganic particles such as glass beads, silica particles, aluminum hydroxide particles, calcium carbonate particles, barium sulfate particles, titanium oxide particles, and talc can be used.

Among these, at least one selected from the group consisting of acrylic polymer particle, styrene-based polymer particle, and siloxane-based polymer particle is preferred.

[0055]

<Manufacturing Method of Light Diffusion Plate>

The light diffusion plate of one embodiment of the present invention can be manufactured by molding the optical styrene-based resin composition by various methods such as extrusion molding and injection molding, and is preferably manufactured by extrusion molding. Examples of the extrusion molding include a method in which the optical styrene-based resin composition is melt-kneaded using a single-screw extruder or a twin-screw extruder, continuously extruded through a T-die, and then cooled and solidified using a cooling roll unit. When forming a concave-convex shape on the surface of a light diffusion plate, a transfer mold is provided on the surface of the cooling roll, and an arbitrary concave-convex shape can be formed by changing the shape of the transfer mold. When the surface layer is laminated on either or both sides of the light diffusion plate, methods such as co-extrusion method, pasting method, thermal adhesion method, solvent adhesion method, casting method, and surface coating method can be used.

[0056]

5. Direct-light Type Planer Light Source Unit

The direct-light type planer light source unit of one embodiment of the present invention is a direct-light type planer light source unit having the above-mentioned light diffusion plate and a light source which supplies LED light to the light diffusion plate. The direct-light type planer light source unit is suitably used as a planer light source device for liquid crystal display devices.

Examples

[0057]

Hereinafter, the present invention will be explained in further detail with reference to Examples. However, these Examples are merely for exemplification, and shall not limit the scope of the present invention.

[0058]

1. Manufacture of Optical Styrene-based Resin Composition

[Example 1]

The first reactor which is a complete stirred agitation tank and the second reactor which is a plug flow reactor with static mixer were connected in series to constitute a polymerization step, and the manufacture of the styrene-based resin was performed. The volumes of each of the reactors were set as 30 liters for the first reactor and 12 liters for the second reactor. With respect to a

raw material composition of 51 mass% of styrene (TBC concentration: 11 µg/g), 39 mass% of methyl methacrylate (TBX concentration: 7 µg/g), and 10 mass% of ethyl benzene, the addition concentration of t-butyl peroxyisopropyl monocarbonate (PERBUTYL I made by NOF CORPORATION) as a polymerization initiator and the addition concentration of n-dodecyl mercaptan (made by Arkema) as a chain transfer agent were adjusted at the inlet of the first reactor to 150 ppm and 500 ppm (both concentrations based on the mass to the all monomers), respectively. The raw material solution was then continuously supplied at 8.0 kg/h to the first reactor set at 128°C. Further, the polymerization solution obtained was continuously supplied to the second reactor to complete the polymerization. The polymerization rate of the monomers was 70%. In the second reactor, a temperature gradient was applied along the flow direction, and the temperature was adjusted so that the middle portion was at 130°C and the outlet portion was at 145°C.

Subsequently, the solution containing the polymer continuously taken out from the second reactor was then introduced into a two-stage sequential vacuum devolatilization tanks equipped with a preheater. The temperature of the preheater was adjusted so that the resin temperature became 220°C, and unreacted styrene and ethylbenzene were separated at a pressure of 0.8 kPa. The obtained molten polymer was continuously supplied to the extruder, and 0.1 parts by mass of the hindered amine light stabilizer (770) was added to 100 parts by mass of the polymer through the additive feed port. Thereafter, mixing was performed at a set temperature of 220°C. The polymer was then extruded into strands from a porous die, and the strands were cooled and cut into pellets by cold cutting method. The TBC concentration and the TBX concentration in the obtained optical styrene-based resin composition were 1.5 µg/g and 0.2 µg/g, respectively. The weight average molecular weight (Mw) was 170,000, and the ratio (Mw/Mn) of weight average molecular weight (Mw) to number average molecular weight (Mn) was 2.0.

[0059]

[Examples 2 to 17 and Comparative Examples 1 to 6]

The optical styrene-based resin compositions and the light guide plates were manufactured in the same manner as in Example 1, except that the composition of the raw material solution and polymerization conditions were changed as shown in Table 1, and the formulations of the hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), phenol-based antioxidant (C-2), and the UV absorber (D) were changed as shown in Table 2 (Table 2-1 and Table 2-2) to Table 3. The results of various measurements and evaluations are shown in Table 2 (Table 2-1 and Table 2-2) to Table 3.

Table 1		Condition 1	Condition 2	Condition 3	Condition 4	Condition 5	Condition 6
Resin Name		A-1	A-2	A-3	A-4	A-5	A-6
Raw Material Supply Flow Rate		kg/hr	8.0	8.0	8.0	8.0	8.0
Composition of Raw Material	Styrene	51.0	65.5	79.0	27.0	90.0	10.0
	Methyl Methacrylate	39.0	24.5	11.0	63.0	0.0	80.0
	Ethylbenzene	10.0	10.0	10.0	10.0	10.0	10.0
Polymerization Initiator		ppm *1	150	150	100	250	100
Chain Transfer Agent		ppm *1	500	100	2800	-	4000
Reaction Temperature	First Reactor	°C	128	140	130	130	125
	Second Reactor (Middle Portion)	°C	130	140	130	135	130
	Second Reactor (Outlet Portion)	°C	145	165	145	150	145
Devolatilization Tank	Resin Temperature	°C	220	220	220	220	220
	Pressure	kPa	0.8	0.8	0.8	0.8	0.8
Addition of Stabilizer	Addition Method	- *2	EXT	EXT	EXT	EXT	EXT
	Resin Temperature	-	220	220	220	220	220

*1 Concentration Based on Mass to All Monomers

Polymerization Initiator : t-Butyl Peroxyisopropyl Monocarbonate

Chain Transfer Agent : n-Dodecyl Mercaptan

*2 EXT : Extruder

[0061]

[Table 2-1]

Table 2-1			Unit	Example									
				1	2	3	4	5	6	7	8	9	
Resin Composition Formulation	Styrene-based Resin (A)	Type	-	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	
		PMMA Amount	mass%	47	47	47	47	47	47	47	47	47	
		Addition Amount	parts by mass	100	100	100	100	100	100	100	100	100	
	Hindered Amine Light Stabilizer (B)	Type	-	770	944	292	292	292	123	944	292	292	
		Addition Amount	parts by mass	0.1	0.1	0.01	0.05	0.1	0.1	0.1	0.05	0.1	
		Type	-	-	-	-	-	-	-	168	168	168	
	Antioxidant (C)	Phosphorus-based Antioxidant (C-1)	parts by mass	-	-	-	-	-	-	-	0.05	0.2	0.05
		Phenol-based Antioxidant (C-2)	Type	-	-	-	-	-	-	-	-	-	-
Resin Characteristics	Addition Amount		parts by mass	-	-	-	-	-	-	-	-	-	
	Melt Mass Flow Rate		g/10min	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	
	Mw		×10 ⁴	17	17	17	17	17	17	17	17	17	
	Mw/Mn		-	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0	
	TBC Content		μ/g	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	
	TBX Content		μ/g	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	
	Light Guide Plate Characteristics	Optical Characteristics at Optical Path Length of 115 mm	Average Transmittance	-	88	88	89	89	89	85	90	90	90
Dimensional Stability (Deformation due to Moisture Absorption)		YI Value	-	3.8	4.0	2.4	2.5	2.8	6.0	3.8	2.3	2.5	
		LED Durability (500 hr)	-	A	A	A	A	A	A	A	A	A	A
			ΔYI	-	0.9	0.9	0.8	0.8	0.6	2.0	0.7	0.7	0.5
		Presence or Absence of Carbonization	-	A	A	A	A	A	A	A	A	A	

[0062]

[Table 2-2]

Table 2-2		Unit	Example									
			10	11	12	13	14	15	16	17		
Resin Composition Formulation	Styrene-based Resin (A)	Type	A-1	A-1	A-1	A-1	A-1	A-2	A-3	A-4		
		PMMA Amount	47	47	47	47	47	32	15	70		
		Addition Amount	100	100	100	100	100	100	100	100		
	Hindered Amine Light Stabilizer (B)	Type	292	292	292	292	944	292	292	292		
		Addition Amount	0.1	0.1	0.1	0.1	0.3	0.1	0.1	0.1		
		Type	HP-10	126	168	HP-10	168	168	168	168		
		Addition Amount	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05		
Resin Characteristics	Antioxidant (C)	Phosphorus-based Antioxidant (C-1)										
		Phenol-based Antioxidant (C-2)										
	Melt Mass Flow Rate		1.7	1.7	1.7	1.7	1.9	2.5	3.5	1.7		
	Vicat Softening Temperature		101	101	101	101	100	100	99	103		
	Mw		17	17	17	17	17	18	21	11		
	Mw/Mn		2.0	2.0	2.0	2.0	2.0	1.9	2.2	2.1		
	TBC Content		1.5	1.5	1.5	1.5	1.5	1.9	2.3	0.8		
	TBX Content		0.2	0.2	0.2	0.2	0.2	0.1	0.1	0.3		
	Optical Characteristics at Optical Path Length of 115 mm	Average Transmittance	90	90	90	90	87	89	88	91		
		YI Value	2.3	2.5	2.5	2.5	4.5	2.5	3.0	1.2		
Light Guide Plate Characteristics	Dimensional Stability (Deformation due to Moisture Absorption)		A	A	A	A	A	A	A	B		
	LED Durability (500 hr)	ΔYI	0.2	0.5	1.0	1.0	0.7	1.0	2.1	0.2		
		Presence or Absence of Carbonization	A	A	A	A	A	A	A	A		

[0063]

[Table 3]

Table 3			Unit	Comparative Example						
				1	2	3	4	5	6	
Resin Composition Formulation	Styrene-based Resin (A)	Type	-	A-5	A-1	A-1	A-1	A-1	A-6	A-1
		PMMA Amount	mass%	0	47	47	47	47	89	47
		Addition Amount	parts by mass	100	100	100	100	100	100	100
		Type	-	-	-	-	944	944	-	
	Hindered Amine Light Stabilizer (B)	Addition Amount	parts by mass	0	0	0	0	1.2	0.1	0
		Type	-	168	-	168	-	-	168	-
		Addition Amount	parts by mass	0.05	-	-	0.015	-	0.05	-
		Type	-	1076	-	1076	-	-	-	-
	Antioxidant (C)	Addition Amount	parts by mass	0.05	-	0.05	-	-	-	-
		Type	-	-	-	-	-	-	-	P
Resin Characteristics	UV Absorber (D)		parts by mass	-	-	-	-	-	-	0.1
	Addition Amount		parts by mass	-	-	-	-	-	-	-
	Melt Mass Flow Rate		g/10min	1.7	1.7	1.7	2.1	1.3	1.3	1.3
	Vicat Softening Temperature		°C	99	101	101	99	104	104	104
	Mw		×10 ⁴	32	17	17	17	8	17	17
	Mw/Mn		-	2.2	2.0	2.0	2.0	1.9	2.0	2.0
	TBC Content		μ/g	2.6	1.5	1.5	1.5	0.4	1.5	1.5
	TBX Content		μ/g	0.0	0.2	0.2	0.2	0.4	0.2	0.2
	Optical Characteristics at Optical Path Length of 115 mm		-	85	84	88	82	86	85	85
	Average Transmittance YI Value		-	5.5	6.0	4.0	8.2	4.6	5.0	5.0
Light Guide Plate Characteristics	Dimensional Stability (Deformation due to Moisture Absorption)		-	A	A	A	A	C	A	A
	ΔYI		-	-	-	-	0.7	0.2	-	-
	LED Durability (500 hr)		-	B	B	B	A	A	A	B
		Presence or Absence of Carbonization								

[0064]

The hindered amine light stabilizer (B), the phosphorus-based antioxidant (C-1), the phenol-based antioxidant (C-2), and the UV absorber (D) in Table 2 (Table 2-1 and Table 2-2) to Table 3 are as follows.

[0065]

(Hindered Amine Light Stabilizer (B))

770: bis(2,2,6,6-tetramethylpiperidin-4-yl)sebacate (TINUVIN 770DF made by BASF)

944: polycondensate of 2,4-dichloro-6-(1,1,3,3-tetramethylbutylamino) and 1,3,5-triazine/N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine (Chimassorb944FDL made by BASF)

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

123: bis(1-octyloxy-2,2,6,6-tetramethylpiperidyl)sebacate (TINUVIN 123 made by BASF)

[0066]

(Phosphorus-based Antioxidant (C-1))

168: tris(2,4-di-tert-butylphenyl)phosphite (Irgafos 168 made by BASF)

HP-10: 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy)(2-ethylhexyloxy)phosphorus (ADKSTAB HP-10 made by ADEKA)

126: bis-(2,4-di-tert-butylphenyl)pentaerythritol diphosphite (Irgafos 126 made by BASF)

[0067]

(Phenol-based Antioxidant (C-2))

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

[0068]

(UV Absorber (D))

P: 2-(2-hydroxy-5-methylphenyl)benzotriazole (TINUVIN P made by BASF)

[0069]

2. Evaluation

The optical styrene-based resin compositions shown in Tables 2 (Tables 2-1 and 2-2) to 3 were evaluated by the following methods.

[0070]

<Melt Mass Flow Rate (MFR)>

The melt mass flow rate was measured in accordance with JIS K 7210 under the conditions of a temperature of 200°C and a load of 49 N.

[0071]

<Vicat Softening Temperature>

The Vicat softening temperature was measured in accordance

with JIS K 7206 under conditions of a heating rate of 50°C/hr and a testing load of 50 N.

[0072]

<TBC Content and TBX Content in Optical Styrene-based Resin Composition>

After dissolving 0.2 g of the optical styrene-based resin composition in a small amount of THF, 200 µL of BSTFA (M,O-bis(trimethylsilyl)(trifluoro acetamide) was added to perform trimethylsilyl-derivatization treatment. Subsequently, the volume was fixed to 10 mL with THF, and the supernatant solution separated by centrifugation was analyzed with gas chromatography mass spectrometry (GC/MS) under the following conditions. Here, the concentration was determined with a calibration curve prepared in advance.

GC equipment: 7890A, made by Agilent Technologies

Column: DB-5ms (0.25 mm i.d. × 30 m), liquid phase film thickness 0.25 µm, made by Agilent Technologies

Column temperature: 50°C (1 min) → (20 °C/min temperature increase) → 320°C (6.5 min) total 20 min

Inlet: 300°C, 1.5 mL/min, (split ratio 1:5)

Injection amount: 1 µL

MS equipment: 5975C, made by Agilent Technologies

Interface temperature: 320°C

MS detection conditions: SIM measurement TBC (m/z for quantitative analysis 295, m/z for verification 310)

[0073]

<Contents of Hindered Amine Light Stabilizer (B), Phosphorus-based Antioxidant (B-1), and Phenol-based Antioxidant (B-2) in Optical Styrene-based Resin Composition>

After completely dissolving 1.0 g of the optical styrene-based resin composition in 20 mL of THF, 5 mL of methanol was added dropwise and stirred for 20 minutes. Centrifugation was performed at 4000 rpm for 10 minutes, and the supernatant solution separated by centrifugation was analyzed with gas chromatography (GC) under the following conditions. Here, the concentration was determined with a calibration curve prepared in advance.

GC equipment: GC2010 Plus made by Shimadzu Corporation

Column: DB-1 (30 m × 0.25 mm i.d., df = 0.10 µm)

Column temperature: 240°C (1 min) → (10 °C/min heating rate) → 320°C (15 min)

Inlet: 320°C, 1.02 mL/min (split ratio 1:5)

Injection amount: 1 µL

[0074]

<Molecular Weight>

The weight average molecular weight (Mw), Z average molecular weight (Mz), and number average molecular weight (Mn) were measured using gel permeation chromatography (GPC) under the following

conditions.

GPC equipment: Shodex GPC-101, made by Showa Denko K.K.

Column: PLgel 10 μ m MIXED-B, made by Polymer Laboratories Inc.

Mobile phase: tetrahydrofuran

Sample concentration: 0.2 mass%

Temperature: oven 40°C, inlet 35°C, detector 35°C

Detector: refractive index detector

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 monodisperse polystyrene.

[0075]

3. Manufacture and Evaluation of Light Guide Plate

<Manufacture of Light Guide Plate>

The optical styrene-based resin composition was supplied to a single-screw extruder equipped with a vent having a screw diameter of 90 mm and L/D of 32. The styrene-based resin composition was melt-kneaded at 200 to 235°C, followed by discharge from a T-die having a lip width of 1000 mm and lip-opening degree of 3.0 mm at a T-die temperature of 245 to 250°C. The discharged resin composition was cooled and solidified using a vertical arranged three roll mill, and then the end surface was trimmed to obtain a light guide plate with a width of 800 mm and a thickness of 2.0 mm.

[0076]

<Evaluation of Light Guide Plate>

The average transmittance, YI value, dimensional stability (deformation due to moisture absorption), and LED durability of the light guide plates in Tables 2 to 3 were evaluated as follows.

[0077]

<Average Transmittance and YI Value of Light Guide Plate>

The average transmittance and YI value were measured by the following method.

A test piece of 115 mm $\times$ 85 mm was cut from the light guide plate obtained above, and the end surface was polished by buffing to prepare a plate-shaped molded article with a mirror surface on the end surface. The spectral transmittance of the polished plate-shaped molded article was measured using an ultraviolet-visible spectrophotometer V-670 made by JASCO Corporation at an optical path length of 115 mm and at a wavelength of 350 nm to 800 nm, in which the size of the incident light was 20 $\times$ 1.6 mm, and a spread angle of the incident light was 0°. The YI value for C light source with visual field of 2° was calculated in accordance with JIS K7105. The average transmittance (total light transmittance) was calculated as an average of spectral transmittance at 380 to 780 nm.

[0078]

<Dimensional Stability (Deformation due to Moisture Absorption)>

A test piece of 200 mm × 300 mm was cut from the light guide plate obtained above, and stored for 500 hours at a temperature of 60°C and a relative humidity of 90%. The change in the dimension of the long side before and after storage was measured, and the deformation rate was calculated using 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 (deformation due to moisture absorption) of the light guide plate was evaluated, while taking a deformation rate of less than 0.10% as "A", a deformation rate of 0.10 to 0.15% as "B", and a deformation rate of more than 0.15% as "C".

[0079]

<LED Durability>

A test piece of 115 mm × 85 mm was cut from the light guide plate obtained above, and the end surface was polished by 0.2 mm using a diamond blade rotating at 8000 rpm and at a feed speed of 2.0 m/min using an end surface polishing machine (GCPB-500 made by MEGARO TECHNICA CO.,LTD) to prepare a plate-shaped molded article with a mirror surface on the end surface. A flat type blue LED light source for TVs (peak wavelength: 445 nm) was placed 0.5 mm from the end surface of the plate-shaped molded article after polishing, and the LED light was irradiated for 500 hours at an input current of 0.05 W/mm² in an environment at 80°C. For the plate-shaped molded article after testing, the spectral transmittance was measured using an ultraviolet-visible spectrophotometer V-670 made by JASCO Corporation at an optical path length of 115 mm and at a wavelength of 350 nm to 800 nm, in which the size of the incident light was 20 × 1.6 mm, and the spread angle of the incident light was 0°. The YI value for C light source with visual field of 2° was calculated in accordance with JIS K7105. The value obtained by subtracting the YI value before testing from the YI value after testing was taken as ΔYI. The LED light-entering portion of the plate-shaped molded article after testing was visually checked, and the LED durability was evaluated by assigning "A" to those showing no change and "B" to those showing the occurrence of carbonization.

[0080]

In Examples 1 to 17, the transparency, hue, and dimensional stability were good, no carbonization occurred after exposure to LED light, and the hue stability was excellent.

CLAIMS

1. An optical styrene-based resin composition, containing a styrene-based resin (A) and a hindered amine light stabilizer (B), wherein:

the styrene-based resin (A) is a copolymer containing a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit;

the copolymer contains 95 to 20 mass% of the styrene-based monomer unit and 5 to 80 mass% of the (meth)acrylic acid ester-based monomer unit in 100 mass% of the copolymer; and

the optical styrene-based resin composition contains 0.001 to 1.0 parts by mass of the hindered amine light stabilizer (B) with respect to 100 parts by mass of the styrene-based resin (A).

2. The optical styrene-based resin composition of Claim 1, wherein the hindered amine light stabilizer (B) is an N-H type hindered amine light stabilizer and/or an N-R type hindered amine light stabilizer.

3. The optical styrene-based resin composition of Claim 2, wherein the N-H type hindered amine light stabilizer is at least one selected from a group consisting of: bis(2,2,6,6-tetramethylpiperidin-4-yl)sebacate; 2,2,6,6-tetramethyl-4-piperidyl hexadecanoate; 2,2,6,6-tetramethyl-4-piperidyl octadecenoate; tetrakis(2,2,6,6-tetramethyl-4-piperidyl)-1,2,3,4-butanetetracarboxylate; polycondensate of N,N'-bis(2,2,6,6-tetramethylpiperidin-4-yl)hexamethylenediamine and 4-morpholino 2,6-dichloro-1,3,5-triazine; polycondensate of 2,4-dichloro-6-(1,1,3,3-tetramethylbutylamino) and 1,3,5-triazine/N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine; 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-piperidinamine; 1,6,11-tris[2,4-bis(N-butyl-N-(2,2,6,6-tetramethyl-4-piperidyl)amino)-s-triazin-6-yl]aminoundecane; and 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.

4. The optical styrene-based resin composition of Claim 2 or 3, wherein the N-R type hindered amine light stabilizer is at least one selected from a group consisting of: methyl(1,2,2,6,6-pentamethylpiperidin-4-yl)sebacate; bis(1,2,2,6,6-pentamethylpiperidin-4-yl)sebacate; bis(1,2,2,6,6-pentamethylpiperidin-4-yl) n-butyl 3,5-di-tert-butyl 4-hydroxybenzyl malonate; polycondensate of 4-hydroxy-2,2,6,6-tetramethyl-1-piperidineethanol and dimethyl succinate; 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;

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; and a mixture of polycondensate of succinic acid and (4-hydroxy-2,2,6,6-tetramethylpiperidin-1-yl)ethanol with 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.

5. The optical styrene-based resin composition of any one of Claims 1 to 3, containing 0.001 to 0.5 parts by mass of a phosphorus-based antioxidant (C-1) with respect to 100 parts by mass of the styrene-based resin (A).

6. The optical styrene-based resin composition of Claim 5, wherein the phosphorus-based antioxidant (C-1) is at least one selected from a group consisting of: tris(2,4-di-tert-butylphenyl) phosphite; 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy) (2-ethylhexyloxy) phosphorus; bis-(2,4-di-tert-butylphenyl)pentaerythritol diphosphate; 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; and bis(2,4-di-tert-butyl-6-methylphenyl)ethyl phosphite.

7. A light guide plate obtained by molding the optical styrene-based resin composition of any one of Claims 1 to 3.

8. An edge-light type planer light source unit, having the light guide plate of Claim 7 and a light source which supplies LED light to an end surface of the light guide plate.

9. A light diffusion plate obtained by molding the optical styrene-based resin composition of any one of Claims 1 to 3.

10. A direct-light type planer light source unit, having the light diffusion plate of Claim 9 and a light source which supplies LED light to the light diffusion plate.