

DESCRIPTION

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

Technical Field

[0001]

The present invention relates to a styrene-based resin composition, 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 disposed behind the display device and an edge-light type in which a light source is disposed on a side surface thereof. Edge-light type backlights use a component called a light guide plate that guides light from the light source disposed on the side surface toward the front of the display device. Such backlights 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. Furthermore, backlights using a light guide plate are also used as lighting devices, signboards, and the like.

[0003]

Since a 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 PMMA is easily thermally decomposed during molding, there is a problem that appearance defects are likely to occur in a molded article 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 article of a styrene-methyl (meth)acrylate copolymer has poorer hue than PMMA, and when used as a backlight, color unevenness may occur. To solve this problem, Patent Literature 2 proposes a technique in which a specific amount of a blue dye is added to styrene-methyl (meth)acrylate.

Citation List

Patent Literature

[0005]

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

[Patent Literature 2] JP-A-2013-082800

Summary of Invention

Technical Problem

[0006]

In recent years, with the trend toward power saving in backlight units for televisions, monitors, lighting, and the like, it has become necessary to increase brightness with fewer LEDs, and high-brightness LEDs may be used as edge light sources; however, conventional light guide plates made of a styrene-methyl (meth)acrylate copolymer sometimes turned yellow after being lit for a long period of time, depending on the usage environment. When yellowing occurs, it appears as color unevenness in televisions and monitors, and in lighting applications, the initial lighting design cannot be maintained because the color temperature changes.

[0007]

The present invention has been made in view of such problems, and an object thereof is to provide a styrene-based resin composition having excellent transparency, hue, and dimensional stability, and having excellent long-term durability against an LED light source.

[0008]

According to the present invention, provided is a styrene-based resin composition comprising a styrene-based resin (A) which is a copolymer comprising a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit, an antioxidant (B), and an anthraquinone-based colorant (C), wherein:

the antioxidant (B) comprises one or both of a phosphorus-based antioxidant (B-1) and a phosphorus-phenol-based antioxidant (B-2);

the styrene-based resin composition comprises 0.001 to 0.5 parts by mass in total of the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-2) based on 100 parts by mass of the styrene-based resin (A); and

the styrene-based resin composition comprises 0.1 to 150 ppb of the anthraquinone-based colorant (C) with respect to the styrene-based resin (A).

[0009]

The present inventors have conducted intensive studies and, as a result, have found that a styrene-based resin composition containing a styrene-based resin comprising a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit, an antioxidant within a specific range, and an anthraquinone-based colorant simultaneously satisfies requirements for transparency, hue, dimensional stability, and long-term durability against an LED light source, thereby completing the present invention.

[0010]

Various embodiments of the present invention are illustrated below. The embodiments shown below can be combined with each other.

[1] A styrene-based resin composition comprising a styrene-based resin (A) which is a copolymer comprising a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit, an antioxidant (B), and an anthraquinone-based colorant (C), wherein:

the antioxidant (B) comprises one or both of a phosphorus-based antioxidant (B-1) and a phosphorus-phenol-based antioxidant (B-2);

the styrene-based resin composition comprises 0.001 to 0.5 parts by mass in total of the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-2) based on 100 parts by mass of the styrene-based resin (A); and

the styrene-based resin composition comprises 0.1 to 150 ppb of the anthraquinone-based colorant (C) with respect to the styrene-based resin (A).

[2] The styrene-based resin composition of [1], wherein the styrene-based resin (A) comprises 20 to 95 mass% of the styrene-based monomer unit and 5 to 80 mass% of the (meth)acrylic acid ester-based monomer unit, based on 100 mass% of the styrene-based resin (A).

[3] The styrene-based resin composition of [1] or [2], wherein the phosphorus-based antioxidant (B-1) is at least one selected from the group consisting of 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy)(2-ethylhexyloxy)phosphorus, 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, and bis(2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite.

[4] The styrene-based resin composition of any one of [1] to [3], wherein the phosphorus-phenol-based antioxidant (B-2) is 6-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propoxy]-2,4,8,10-tetra-tert-butyl-dibenzo[d,f][1,3,2]dioxaphosphin.

[5] The styrene-based resin composition of any one of [1] to [4], wherein an average transmittance over a wavelength range of 380 to 780 nm at an optical path length of 115 mm is 85% or more, as measured using a test piece prepared by molding the styrene-based resin composition into a test piece having a size of 115 mm × 80 mm and a thickness of 3 mm.

[6] The styrene-based resin composition of any one of [1] to [5], wherein a YI value at an optical path length of 115 mm is 4.0 or less, as measured using a test piece prepared by molding the styrene-based resin composition into a test piece having a size of 115 mm × 80 mm and a thickness of 3 mm.

[7] An edge-light type light guide plate, which is a molded article of the styrene-based resin composition of any one of [1] to [6].

[8] An edge-light type planar light source unit comprising the edge-light type light guide plate of [7] and a light source for supplying light to an end face of the light guide plate.

[9] The edge-light type planar light source unit of [7], wherein the edge-light type planar light source unit is for lighting.

Description of Embodiments

[0011]

Hereinafter, embodiments of the present invention will be described. Various features disclosed in the embodiments described below can be combined with each other. In addition, each feature may independently constitute an invention. Furthermore, among the elements described in the following embodiments, elements that are not defined in the claims are optional and may be omitted. Any number of zeros (for example, one or two zeros) may be added to the end of the numerical values disclosed in the following description. For example, one or two zeros may be added after "1.4" to obtain "1.40" or "1.400".

[0012]

1. Styrene-based resin composition

A styrene-based resin composition according to an embodiment of the present invention is a styrene-based resin composition comprising a styrene-based resin (A), an antioxidant (B), and an anthraquinone-based colorant (C).

[0013]

The styrene-based resin composition may comprise, for example, 95.000 to 99.999 mass%, preferably 98.000 to 99.999 mass%, and more preferably 99.000 to 99.999 mass% of the styrene-based resin (A), based on 100 mass% of the styrene-based resin composition.

[0014]

<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, and is a copolymer comprising a styrene-based monomer unit which is a constitutional unit derived from a styrene-based monomer, and a (meth)acrylic acid ester-based monomer unit which is a constitutional unit derived from a (meth)acrylic acid ester-based monomer. The styrene-based resin (A) is preferably a copolymer comprising 20 to 95 mass% of the styrene-based monomer unit and 5 to 80 mass% of the (meth)acrylic acid ester-based monomer unit, more preferably a copolymer comprising 25 to 90 mass% of the styrene-based monomer unit and 10 to 75 mass% of the (meth)acrylic acid ester-based monomer unit, and even more preferably a copolymer comprising 30 to 85 mass% of the styrene-based monomer unit and 15 to 70 mass% of the (meth)acrylic acid ester-based monomer unit, based on 100 mass% of the styrene-based resin (A). By setting the contents within such ranges, requirements for transparency, hue, and dimensional stability can be simultaneously satisfied. By setting the content of the styrene-based monomer to 95 mass% or less, a light guide plate having excellent transparency and hue can be obtained, and 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. Specifically, 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, 18, 20, 25, 30, 35, 40, 45, 47, 50, 55, 60, 65, 70, 75, or 80 mass%, and may be within a range between any two of the values exemplified herein.

[0015]

The styrene-based resin (A) may comprise, for example, 80 to 100 mass%, preferably 90 to 100 mass%, more preferably 99 to 100 mass%, and particularly preferably (substantially) 100 mass% in total of the styrene-based monomer unit and the (meth)acrylic acid ester-based monomer unit, based on 100 mass% of the styrene-based resin (A). Specifically, the total content of the styrene-based monomer unit and the (meth)acrylic acid ester-based monomer unit based on 100 mass% of the styrene-based resin (A) is, for example, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, or 100 mass%, and may be within a range between any two of the values exemplified herein.

[0016]

Examples of the styrene-based monomer include styrene, α -methylstyrene, o-methylstyrene, p-methylstyrene, m-methylstyrene, ethylstyrene, p-t-butylstyrene, and the like.

These may be used alone or in combination of two or more thereof. The styrene-based monomer is preferably styrene.

[0017]

Examples of the (meth)acrylic acid ester-based monomer (acrylic acid ester-based monomer or methacrylic 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-butylcyclohexyl (meth)acrylate, tricyclodecanyl (meth)acrylate, and adamantyl (meth)acrylate; glycidyl (meth)acrylate; and dicyclopentadienyl (meth)acrylate, and the like. These may be used alone or in combination of two or more thereof. The (meth)acrylic acid ester-based monomer is preferably a (meth)acrylic acid alkyl ester, more preferably a methacrylic acid alkyl ester, and even more preferably methyl methacrylate.

[0018]

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 -ethylenically unsaturated carboxylic acids such as maleic anhydride and fumaric acid; and imides such as phenylmaleimide and cyclohexylmaleimide. These may be used alone or in combination of two or more thereof.

[0019]

The weight average molecular weight (Mw) of the styrene-based resin (A) is preferably 50,000 to 400,000, and more preferably 100,000 to 350,000. Specifically, the weight average molecular weight (Mw) of the styrene-based resin (A) is, for example, 50,000, 100,000, 150,000, 160,000, 170,000, 180,000, 190,000, 200,000, 210,000, 220,000, 230,000, 240,000, 250,000, 300,000, 350,000, or 400,000, and may be within a range between any two of the values exemplified herein. The ratio (Mw/Mn) of the weight average molecular weight (Mw) to the number average molecular weight (Mn) of the styrene-based resin (A) is preferably 1.0 to 3.5, and more preferably 1.5 to 3.0. Specifically, the ratio (Mw/Mn) is, for example, 1.0, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 3.0, or 3.5, and may be within a range between any two of the values exemplified herein. By setting these values within such ranges, requirements for both moldability and strength of a light guide plate can be satisfied. When the weight average molecular weight (Mw) is less than 50,000, the strength of a molded article may become insufficient, and when it exceeds 400,000, the moldability may decrease. Also, when the ratio (Mw/Mn) of the number average molecular weight (Mn) is less than 1.0, the moldability may decrease, and when it exceeds 3.5, the strength of a molded article may decrease.

[0020]

<Antioxidant (B)>

The antioxidant (B) comprises one or both of a phosphorus-based antioxidant (B-1) and a phosphorus-phenol-based antioxidant (B-2).

[0021]

The styrene-based resin composition comprises, based on 100 parts by mass of the styrene-based resin (A), 0.001 to 0.5 parts by mass in total of the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-2), preferably 0.002 to 0.4 parts by mass, and more preferably 0.005 to 0.3 parts by mass. By setting the content within such a range, transparency and hue can be improved. Specifically, the total content of the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-2) based on 100 parts by mass of the styrene-based resin (A) is, for example, 0.001, 0.002, 0.003, 0.004, 0.005, 0.01, 0.02, 0.025, 0.05, 0.075, 0.1, 0.15, 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.

[0022]

The phosphorus-based antioxidant (B-1) is a phosphoric or phosphorous acid ester having no 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 (B-

1) include 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy)(2-ethylhexyloxy)phosphorus, 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, and bis(2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite, and these may be used alone or in combination of two or more thereof.

[0023]

The phosphorus-phenol-based antioxidant (B-2) is a phosphoric or phosphorous acid ester having a phenolic hydroxyl group in its basic skeleton, and is preferably a phosphite ester, which is a trivalent phosphorus compound having a phenolic hydroxyl group in its basic skeleton. Examples of the phosphorus-phenol-based antioxidant (B-2) include 6-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propoxy]-2,4,8,10-tetra-tert-butyl dibenzo[d,f][1,3,2]dioxaphosphin, and the like.

[0024]

The styrene-based resin composition may further comprise, based on 100 parts by mass of the styrene-based resin (A), 0 to 0.5 parts by mass of a phenol-based antioxidant (B-3). When the content of the phenol-based antioxidant (C-3) exceeds 0.5 parts by mass, hue deteriorates, which is not preferable. Specifically, the content of the phenol-based antioxidant (C-3) based on 100 parts by mass of the styrene-based resin (A) is, 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, and may be within a range between any two of the values exemplified herein.

[0025]

The phenol-based antioxidant (B-3) is an antioxidant that has a phenolic hydroxyl group in its basic skeleton and is not a phosphoric or phosphorous acid ester. The phenol-based antioxidant (B-2) is, for example, at least one selected from the group consisting of octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate, ethylenebis(oxyethylene)bis[3-(5-tert-butyl-4-hydroxy-m-tolyl)propionate], pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate], and 3,9-bis[2-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propionyloxy]-1,1-dimethylethyl]-2,4,8,10-tetraoxaspiro[5,5]undecane. These may be used alone or in combination of two or more thereof.

[0026]

<Anthraquinone-based colorant (C)>

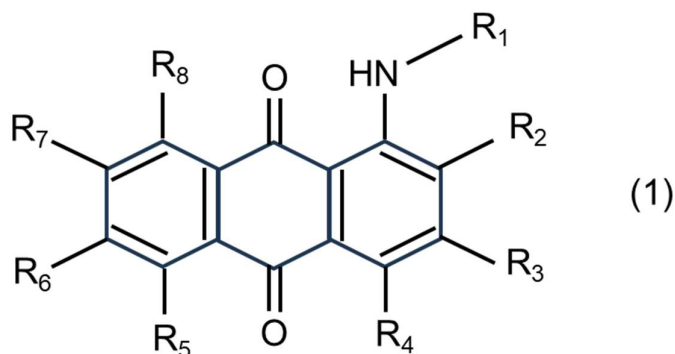
The styrene-based resin composition comprises 0.1 to 150 ppb, preferably 0.5 to 100 ppb, and more preferably 1 ppb or more and less than 75 ppb, of the anthraquinone-based colorant (C) with respect to the styrene-based resin (A). By setting the content within such a range, a styrene-based resin composition having good average transmittance and hue, and excellent long-term stability against an LED light source can be obtained. Specifically, the content of the anthraquinone-based colorant (B) with respect to the styrene-based resin (A) is, for example, 0.1, 0.5, 1, 5, 10, 15, 20, 35, 30, 35, 40, 45, 47, 50, 55, 60, 65, 70, 74, 75, 80, 85, 90, 95, 100, 110, 120, 130, 140, or 150 ppb, and may be within a range between any two of the values exemplified herein. The anthraquinone-based colorant (C) may be used alone or in combination of two or more thereof.

[0027]

The anthraquinone-based colorant (C) is a compound having a structural unit represented by the following general formula (1).

[0028]

[Chem. 1]



[0029]

In the general formula (1), R₁ is a group selected from the group consisting of a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, a cycloalkyl group having 3 to 10 carbon atoms, an aryl group, and an alkoxy group. R₂ to R₈ are each independently a group selected from the group consisting of a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, a cycloalkyl group having 3 to 10 carbon atoms, an aryl group, an alkoxy group, a hydroxyl group, a halogen atom, an amino group, a sulfo group, a carboxyl group, a cyano group, a nitro group, -COR₉, -COOR₉, -NR₉R₁₀, -NR₉COR₁₀, -NR₉SO₂R₁₀, -CONR₉R₁₀, -SO₃R₉, -CONHSO₂R₉, -SO₂NR₉R₁₀, and -SO₂NHCOR₉; and R₉ and R₁₀ are each independently a hydrogen atom, or a group selected from the group consisting of an aliphatic group, an aromatic group, and a heterocyclic group. When -SO₃H and/or -CO₂H are present in the structure, they may form a salt such as a sodium salt or a potassium salt.

[0030]

Examples of the alkyl group having 1 to 10 carbon atoms for R₁ to R₈ include a methyl group, an ethyl group, a propyl group, a butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, an isopropyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, an isopentyl group, a neopentyl group, a 2-ethylhexyl group, and the like, and these alkyl groups may have a substituent such as a hydroxyl group, a halogen atom, an amino group, a sulfo group, a carboxyl group, a cyano group, a nitro group, or a nitrile group.

[0031]

Examples of the cycloalkyl group having 3 to 10 carbon atoms for R₁ to R₈ include a cyclopropyl group, a cyclopentyl group, a cyclohexyl group, a cycloheptyl group, a cyclooctyl group, a tricyclodecyl group, and the like, and these cycloalkyl groups may have a substituent such as a hydroxyl group, a halogen atom, an amino group, a sulfo group, a carboxyl group, a cyano group, a nitro group, or a nitrile group.

[0032]

Examples of the aryl group for R₁ to R₈ include a phenyl group, an o-tolyl group, an m-tolyl group, a p-tolyl group, a cumyl group, a xylyl group, a propylphenyl group, an n-butylphenyl group, a 4-tert-butylphenyl group, and the like, and these aryl groups may have a substituent such as a hydroxyl group, a halogen atom, an amino group, a sulfo group, a carboxyl group, a cyano group, a nitro group, or a nitrile group.

[0033]

Examples of the alkoxy group for R₁ to R₈ include a methoxy group, an ethoxy group, a propoxy group, a butoxy group, a tert-butoxy group, a phenoxy group, a naphthoxy group, and the like, and these alkoxy groups may have a substituent such as a hydroxyl group, a halogen atom, an amino group, a sulfo group, a carboxyl group, a cyano group, a nitro group, or a nitrile group.

[0034]

Specific examples of the anthraquinone-based colorant include the following. Note that the names listed below are Color Index names. Disperse Violet 4, Disperse Violet 8, Disperse Violet 17, Disperse Violet 26, Disperse Violet 28, Disperse Violet 31, Disperse Blue 3, Disperse Blue 14, Disperse Blue 60, Disperse Blue 72, Disperse Blue 134, Disperse Blue 181, Disperse Blue 197, Solvent Violet 11, Solvent Violet 12, Solvent Violet 13, Solvent Violet 26, Solvent Violet

31, Solvent Violet 33, Solvent Violet 34, Solvent Violet 36, Solvent Violet 37, Solvent Violet 38, Solvent Violet 48, Solvent Violet 51, Solvent Violet 59, Solvent Violet 60, Solvent Blue 11, Solvent Blue 12, Solvent Blue 13, Solvent Blue 14, Solvent Blue 16, Solvent Blue 18, Solvent Blue 35, Solvent Blue 36, Solvent Blue 45, Solvent Blue 58, Solvent Blue 59, Solvent Blue 59:1, Solvent Blue 63, Solvent Blue 67, Solvent Blue 68, Solvent Blue 74, Solvent Blue 76, Solvent Blue 78, Solvent Blue 79, Solvent Blue 83, Solvent Blue 90, Solvent Blue 94, Solvent Blue 95, Solvent Blue 97, Solvent Blue 98, Solvent Blue 101, Solvent Blue 102, Solvent Blue 104, Solvent Blue 105, Solvent Blue 111, Solvent Blue 112, Solvent Blue 122, Solvent Blue 128, Solvent Blue 132, Solvent Blue 136, Solvent Blue 146, Acid Blue 27, Acid Blue 43, Acid Blue 47, Acid Blue 49, Acid Blue 51, Acid Blue 55, Acid Blue 145, Mordant Blue 23, Mordant Blue 27, Disperse Green 6:1, Solvent Green 3, Solvent Green 20, Solvent Green 28, Solvent Green 33, and Acid Green 25.

[0035]

<Hindered amine-based light stabilizer (D)>

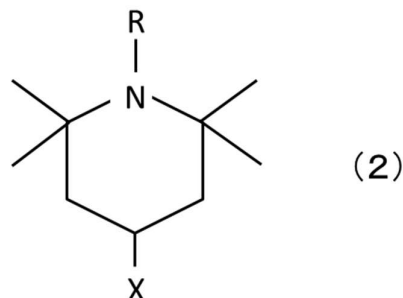
The styrene-based resin composition may comprise a hindered amine-based light stabilizer (D). The styrene-based resin composition preferably comprises 0.001 to 1.0 parts by mass, more preferably 0.001 to 0.5 parts by mass, and even more preferably 0.05 to 0.3 parts by mass of the hindered amine-based light stabilizer (D), based on 100 parts by mass of the styrene-based resin (A). By setting the content within such a range, light stability can be improved. Specifically, the content of the hindered amine-based light stabilizer (D) based on 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-based light stabilizer (D) may be used alone or in combination of two or more thereof.

[0036]

The hindered amine-based light stabilizer (D) is a compound having a structural unit represented by the following general formula (2).

[0037]

[Chem. 2]



[0038]

In the general formula (2), 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 is a hydrogen atom, a linear or branched alkyl group having 1 to 10 carbon atoms, a methylene group, or an alkoxy group. Here, a compound in which R is a hydrogen atom is referred to as an N-H type hindered amine-based light stabilizer; a compound in which 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-based light stabilizer; and a compound in which R is an alkoxy group is referred to as an N-OR type hindered amine-based light stabilizer.

[0039]

Specific examples of the N-H type hindered amine-based 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) and 1,3,5-triazine·N,N'-bis(2,2,6,6-tetramethyl-4-piperidyl)hexamethylenediamine (Chimassorb 944 FDL, 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-piperidinamine (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 2020 FDL, 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]heneicosan-20-yl)propionate, tetradecyl 3-(2,2,4,4-tetramethyl-21-oxo-7-oxa-3,20-diazadispiro[5.1.11.2]heneicosan-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]heneicosan-21-one and epichlorohydrin (HOSTAVIN N30P, manufactured by Clariant).

[0040]

Specific examples of the N-R type hindered amine-based 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 111 FDL, manufactured by BASF).

[0041]

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

[0042]

<Other components>

The content of t-butylcatechol (TBC) in the styrene-based resin composition is preferably 10 ppm or less, and more preferably 5 ppm or less. By setting the content within such a range, a light guide plate having excellent hue and transmittance can be obtained. Specifically, 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.

[0043]

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

[0044]

The styrene-based resin composition may comprise, as long as the characteristics of the present invention are not impaired: 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 blueing agent; and a release agent such as a higher fatty acid (e.g., lauric acid, myristic acid, palmitic acid, or stearic acid), a higher fatty acid amide (e.g., stearic acid amide, erucic acid amide, or ethylene bisstearamide), a higher fatty acid

glyceride (e.g., lauric acid monoglyceride, palmitic acid monoglyceride, stearic acid monoglyceride, or behenic acid monoglyceride), or a higher alcohol (e.g., myristyl alcohol, cetyl alcohol, or stearyl alcohol).

[0045]

The melt mass-flow rate (MFR) of the 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, more preferably 1.0 to 4.5 g/10 min, and even more preferably 1.2 to 4.0 g/10 min. Specifically, the MFR is, for example, 0.5, 1.0, 1.2, 1.5, 1.6, 1.7, 1.8, 1.9, 2.0, 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, 2.9, 3.0, 3.5, 4.0, 4.5, or 5.0, and may be within a range between any two of the values exemplified herein. When the MFR is less than 0.5 g/10 min, the molding (extrusion) stability may decrease, and when the MFR exceeds 5.0 g/10 min, the strength may become insufficient.

[0046]

The Vicat softening temperature (measured at a heating rate of 50°C/hr and a test load of 50 N) of the styrene-based resin composition is preferably 95°C or higher, and more preferably 98°C or higher. When the Vicat softening temperature is less than 95°C, heat resistance is insufficient, and a light guide plate may deform depending on the usage environment. The upper limit of the Vicat softening temperature is, for example, 130°C, or may be 104°C.

[0047]

The average transmittance over a wavelength range of 380 to 780 nm at an optical path length of 115 mm is preferably 85% or more, and more preferably 86% or more, as measured using a test piece prepared by molding the styrene-based resin composition into a test piece having a size of 115 mm × 80 mm and a thickness of 3 mm. Specifically, the average transmittance (before the long-term durability test) is, for example, 85, 86, 87, 88, 89, 90, or 95%, and may be within a range between any two of the values exemplified herein. Also, the average transmittance over a wavelength range of 380 to 780 nm at an optical path length of 115 mm after the long-term durability test (storage in an oven at 80°C for 1000 hours), as measured using the test piece, is preferably 85% or more. Specifically, the average transmittance (after the long-term durability test) is, for example, 85, 86, 87, 88, 89, 90, or 95%, and may be within a range between any two of the values exemplified herein.

[0048]

The YI value (YI1) at an optical path length of 115 mm is preferably 5.0 or less, more preferably 4.0 or less, and even more preferably 3.0 or less, as measured using a test piece prepared by molding the styrene-based resin composition into a test piece having a size of 115 mm × 80 mm and a thickness of 3 mm. Specifically, the YI value (YI1) is, for example, 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, or 5.0, and may be within a range between any two of the values exemplified herein. Also, the YI value (YI2) at an optical path length of 115 mm after the long-term durability test (storage in an oven at 80°C for 1000 hours), as measured using the test piece, is preferably 5.0 or less, more preferably 4.0 or less, and even more preferably 3.5 or less. Specifically, the YI value (YI2) is, for example, 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, or 5.0, and may be within a range between any two of the values exemplified herein. In addition, ΔYI (YI2-YI1) is preferably 2.0 or less, more preferably 1.5 or less, and even more preferably 1.0 or less.

[0049]

<Method for producing styrene-based resin composition>

Examples of a polymerization method for the styrene-based resin (A) include known styrene polymerization methods such as a bulk polymerization method, a solution polymerization method, a suspension polymerization method, and an emulsion polymerization method.

From the viewpoints 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; and aliphatic hydrocarbons such as hexane and cyclohexane may be used.

[0050]

During the polymerization of the styrene-based resin (A), a polymerization aid such as a polymerization initiator, a chain transfer agent, or a cross-linking agent, or other

polymerization aids may be used as necessary. As the polymerization initiator, a radical polymerization initiator is preferable, and examples thereof include known and commonly used initiators such as: peroxyketals (e.g., 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 (e.g., cumene hydroperoxide and t-butyl hydroperoxide); alkyl peroxides (e.g., t-butyl peroxyacetate and t-amyl peroxyisononanoate); dialkyl peroxides (e.g., t-butylcumyl peroxide, di-t-butyl peroxide, dicumyl peroxide, and di-t-hexyl peroxide); peroxyesters (e.g., t-butyl peroxyacetate, t-butyl peroxybenzoate, and t-butyl peroxyisopropyl monocarbonate); peroxyarbonates (e.g., t-butyl peroxyisopropyl carbonate and polyether tetrakis(t-butyl peroxyarbonate)); and N,N'-azobis(cyclohexane-1-carbonitrile), N,N'-azobis(2-methylbutyronitrile), N,N'-azobis(2,4-dimethylvaleronitrile), and N,N'-azobis[2-(hydroxymethyl)propionitrile], and one or two or more thereof may be used in combination.

As the chain transfer agent, for example, 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 a hydroxyl group of a polyhydric alcohol such as ethylene glycol, tetraethylene glycol, neopentyl glycol, trimethylolpropane, pentaerythritol, dipentaerythritol, tripentaerythritol, or sorbitol with thioglycolic acid or mercaptopropionic acid; pentaphenylethane; α -methylstyrene dimer; and terpinolene may be mentioned. Among these, aliphatic mercaptans, aromatic mercaptans, thiocarboxylic acids, and polyfunctional mercaptans are preferable because molecular weight adjustment is easy.

[0051]

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

[0052]

First, in the polymerization step, a known completely mixed tank type stirring tank, a tower type reactor, or the like is used, and the polymerization reaction is controlled by adjusting the polymerization temperature or the like so as to achieve a target molecular weight, a molecular weight distribution, and a reaction conversion rate.

[0053]

A polymerization solution containing a polymer obtained in the polymerization step is transferred to the devolatilization step, and unreacted monomers and a polymerization solvent are removed. The devolatilization step is performed using a vacuum devolatilization tank with a heater, a devolatilization extruder with a vent, or the like. The polymer in a molten state obtained in the devolatilization step is transferred to the granulation step. In the granulation step, the molten resin is extruded in a strand shape from a multi-hole die and processed into a pellet shape by a cold cut method, an in-air hot cut method, or an underwater hot cut method.

[0054]

The styrene-based resin composition may be produced by adding the antioxidant (B) and the anthraquinone-based colorant (C) to the styrene-based resin (A). The antioxidant (B) and the anthraquinone-based colorant (C) may be added to a raw material solution before the polymerization of the styrene-based resin (A), or may be mixed using an extruder or a static mixing device installed after the polymerization of the styrene-based resin (A) and before granulation. Alternatively, the styrene-based resin composition may be produced by dry-blending the styrene-based resin (A) in the form of pellets after granulation with the antioxidant (B) and the anthraquinone-based colorant (C), followed by melt-kneading. Further, the styrene-based resin composition may be adjusted by preparing a pellet-shaped masterbatch obtained by previously melt-kneading the antioxidant (B) and the anthraquinone-based colorant (C) with a small amount of a styrene-based resin, dry-blending the styrene-based resin (A) with the masterbatch, and then melt-kneading the mixture.

[0055]

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

[0056]

2. Light guide plate

A light guide plate according to an embodiment of the present invention is a molded article formed by molding the styrene-based resin composition. The light guide plate can be used for various applications, and can be suitably used particularly for an edge-light type planar light source unit. The edge-light type planar light source unit may be, for example, a unit for lighting, and the light guide plate may be a light guide plate for lighting used in the unit.

[0057]

<Shape of light guide plate>

The light guide plate may have an uneven shape on a surface thereof. More specifically, the light guide plate may have a plurality of lenticular-shaped and/or prism-shaped convex portions on the surface thereof. The convex portions are preferably provided on at least one surface of the light guide plate, and are particularly provided on one surface that is a front surface (light-emitting surface) of the light guide plate. The convex portions may also be provided on other surfaces if necessary, but are more preferably provided only on the front surface (light-emitting surface) of the light guide plate.

[0058]

Here, the lenticular-shaped convex portion is an arc-shaped convex portion, and is a ridge whose cross-sectional edge shape is an arc shape. Further, the prism shape is a convex portion, and is a ridge whose cross-sectional edge shape is a triangular mountain shape. In addition, a plurality of the convex portions can be formed so as to be in a parallel relationship with each other. In addition, the convex portions can be formed integrally with the light guide plate.

[0059]

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. Within such a range, it is easy to produce a light guide plate excellent in moldability such as excellent extrusion stability and in strength, in the molding of the styrene-based resin composition.

[0060]

<Optical characteristics>

The average transmittance of the light guide plate over a wavelength range of 380 to 780 nm at an optical path length of 115 mm is preferably 85% or more, and more preferably 86% or more. Also, the average transmittance of the light guide plate over a wavelength range of 380 to 780 nm at an optical path length of 115 mm after a long-term durability test (storage in an oven at 80°C for 1000 hours) is preferably 85% or more.

[0061]

The YI value (YI1) of the light guide plate at an optical path length of 115 mm is preferably 5.0 or less, more preferably 4.0 or less, and even more preferably 3.0 or less. Specifically, the YI value (YI1) is, for example, 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, or 5.0, and may be within a range between any two of the values exemplified herein. Also, the YI value (YI2) of the light guide plate at an optical path length of 115 mm after the long-term durability test (storage in an oven at 80°C for 1000 hours) is preferably 5.0 or less, more preferably 4.0 or less, and even more preferably 3.5 or less. Specifically, the YI value (YI2) is, for example, 0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, or 5.0, and may be within a range between any two of the values exemplified herein. In addition, ΔYI (YI2-YI1) is preferably 2.0 or less, more preferably 1.5 or less, and even more preferably 1.0 or less.

[0062]

<Method for producing light guide plate>

A light guide plate according to an embodiment of the present invention is a molded article formed by molding the styrene-based resin composition described above. As a molding method, a known method such as sheet extrusion molding, injection molding, or compression molding can be used, but continuous sheet extrusion molding equipped with a surface shape transfer mold is preferable from the viewpoints of productivity and ease of increasing the size of a molded article. Examples of sheet extrusion molding include a continuous sheet extrusion molding method comprising: an extrusion step of supplying a resin in a heated and molten state to a feed block and continuously extruding the resin from a die to prepare a sheet; a pressing step of sandwiching the resin sheet between a pressure roll and a cooling roll; and a conveying

step of conveying the resin sheet while keeping the resin sheet in close contact with the cooling roll after the pressing step, wherein a transfer mold is provided on a surface of the cooling roll, and an arbitrary uneven shape can be transferred to a surface of the sheet by changing a shape of the transfer mold.

[0063]

In addition, the light guide plate may have an uneven shape on a front surface (light-emitting surface), and a back surface thereof can be subjected to a reflection treatment for diffusely reflecting light. Examples of the reflection treatment include a method of imparting dot-shaped unevenness by laser irradiation in addition to silk printing and inkjet printing, and an ink having fine particles that diffuse light can be used for printing a dot pattern.

[0064]

3. Edge-light type planar light source unit

An edge-light type planar light source unit according to an embodiment of the present invention is an edge-light type planar light source unit comprising the light guide plate and a light source for supplying 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 lighting, a liquid crystal display device, or the like.

Examples

[0065]

The present invention will be described in more detail below with reference to Examples. However, these Examples are merely illustrative and are not intended to limit the scope of the present invention.

[0066]

1. Preparation of styrene-based resin composition

[Example 1]

A polymerization step was carried out by connecting a first reactor, which is a completely mixed tank type stirring tank, and a second reactor, which is a plug flow type reactor equipped with a static mixer, in series to produce a styrene-based resin. The capacity of each reactor was set to 30 liters for the first reactor and 12 liters for the second reactor. A raw material solution was prepared such that the composition of the raw materials was 65 mass% of styrene (TBC concentration: 11 µg/g), 25 mass% of methyl methacrylate (TBX concentration: 7 µg/g), and 10 mass% of ethylbenzene, and the addition concentration of t-butyl peroxyisopropyl monocarbonate (manufactured by NOF Corporation: PERBUTYL I) as a polymerization initiator and the addition concentration of n-dodecyl mercaptan (manufactured by Arkema K.K.) as a chain transfer agent were adjusted to 100 ppm and 150 ppm, respectively, at the inlet of the first reactor (both concentrations are based on the mass of the raw material styrene). The raw material solution was then continuously supplied to the first reactor set at 135°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 polymerization rate of the monomers at this time was 70%. In the second reactor, a temperature gradient was provided along the flow direction so that the temperature was 135°C at an intermediate portion and 145°C at an outlet portion. Subsequently, the solution containing the polymer continuously taken out from the second reactor was introduced into a vacuum devolatilization tank equipped with preheaters and composed of two stages in series, the temperature of the preheaters was adjusted so that the resin temperature became 240°C, and unreacted styrene and ethylbenzene were separated at a pressure of 0.8 kPa. The obtained molten polymer was continuously supplied to an extruder, and 0.2 parts by mass of a phosphorus-based antioxidant (168) and 0.1 parts by mass of a phosphorus-phenol-based antioxidant (GP) based on 100 parts by mass of the polymer, and an anthraquinone-based colorant (SV13) in an amount of 47 ppb with respect to the polymer, were added from an additive feed port. After mixing at a set temperature of 220°C, the mixture was extruded in a strand shape from a multi-hole die, and the strands were cooled and cut into pellets by a cold cut method.

[0067]

[Examples 2 to 18 and Comparative Examples 1 to 8]

Styrene-based resin compositions and light guide plates 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 formulations of the phosphorus-based antioxidant (B-1), the phosphorus-phenol-based antioxidant (B-2), the phenol-based antioxidant (B-3), the anthraquinone-based colorant (C), and the hindered amine-based light stabilizer (D) were changed as shown in Tables 2 to 4. The contents of the phosphorus-based antioxidant (B-1), the phosphorus-phenol-based antioxidant (B-2), the phenol-based antioxidant (B-3), and the hindered amine-based light stabilizer (D) are contents based on 100 parts by mass of the polymer (styrene-based resin), and the content of the anthraquinone-based colorant (C) is based on the polymer (styrene-based resin). Various measurement and evaluation results are shown in Tables 2 to 4.

[0069]
[Table 2]

[0070]
[Table 3]

[0071]
[Table 4]

Table 4		Unit	Comparative Examples							
			1	2	3	4	5	6	7	8
Resin Composition	Styrene-Based Resin (A)	Type	A-1	A-1	A-3	A-3	A-4	A-5	A-6	A-6
		MMA Unit Content	30	30	18	18	47	75	0	0
	Phosphorus-Based Antioxidant (B-1)	Type	168	168	168	-	-	38	HP-10	-
		Amount Added	0.05	0.05	0.05	-	-	0.02	0.1	-
	Phosphorus-Phenol-Based Antioxidant (B-2)	Type	GP	GP	GP	-	-	GP	-	-
		Amount Added	0.025	0.025	0.025	-	-	0.05	-	-
	Phenol-Based Antioxidant (B-3)	Type	-	-	-	-	-	-	1076	-
		Amount Added	-	-	-	-	-	-	0.1	-
	Anthraquinone-Based Colorant (C)	Type	-	SV13	-	-	-	-	B	-
		Amount Added	-	170	-	-	-	-	47	-
Resin Composition Properties	Hindered Amine-Based Light Stabilizer (D)	Type	-	-	-	-	-	-	-	-
		Amount Added	-	-	-	-	-	-	-	-
	Melt Mass-Flow Rate	g/10 min	2.5	2.5	1.8	1.8	1.9	2.2	1.0	1.0
	Vicat Softening Temperature	°C	100	100	100	100	100	102	99	99
	Initial Hue	Average Transmittance	86	83	86	86	88	90	84	84
		YI Value	4.2	-4.5	4.5	4.8	2.5	1.8	6.1	6.1
	Hue after Long-Term Durability Test (80°C × 1,000 h)	Average Transmittance	85	82	86	85	85	88	83	83
		YI Value	7.2	-1.5	9.5	11.2	6.0	3.3	9.1	13.1
		ΔYI	3.0	3.0	5.0	6.4	3.5	1.5	3.0	7.0
	Extrusion Stability (Surging)	-	A	A	B	B	B	B	C	C
Light Guide Plate Properties	Color Temperature Change (after 5,000 hrs of Lighting)	-	C	C	C	D	C	C	C	D
	Dimensional Stability (Hygroscopic Deformation)	-	B	B	B	B	C	D	B	B

[0072]

The phosphorus-based antioxidant (B-1), the phosphorus-phenol-based antioxidant (B-

2), the anthraquinone-based colorant (C), and the hindered amine-based light stabilizer (D) in Tables 2 to 3 are as follows.

[0073]

(Phosphorus-based antioxidant (B-1))

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

6260: Bis(2,4-di-tert-butylphenyl) pentaerythritol diphosphite (Songnox 6260, manufactured by SONGWON)

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

[0074]

(Phosphorus-phenol-based antioxidant (B-2))

GP: 6-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propoxy]-2,4,8,10-tetra-tert-butylidibenzo[d,f][1,3,2]dioxaphosphepin (Sumilizer GP, manufactured by Sumitomo Chemical Co., Ltd.)

[0075]

(Phenol-based antioxidant (B-3))

245: Ethylenebis(oxyethylene)bis[3-(5-tert-butyl-4-hydroxy-m-tolyl)propionate] (Irganox 245, manufactured by BASF Japan Ltd.)

1010: Pentaerythritol tetrakis[3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate] (Irganox 1010, manufactured by BASF Japan Ltd.)

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

[0076]

(Anthraquinone-based colorant (C))

SV13 (Solvent Violet 13): 1-Hydroxy-4-(4-methylphenylamino)anthracene-9,10-dione (Macrolex Violet B Gran, manufactured by LANXESS)

SV33 (Solvent Violet 33): (Diaresin Blue J, manufactured by Mitsubishi Chemical Corporation)

SB45 (Solvent Blue 45): 3,3'-[(9,10-Dihydro-9,10-dioxo-1,4-anthracene)diimino]bis[N-cyclohexyl-2,4,6-trimethylbenzenesulfonamide] (Transparent Blue S-RLS, manufactured by EPSILON)

[0077]

(Hindered amine-based light stabilizer (D))

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

[0078]

2. Evaluation

The measurement and evaluation of the resin characteristics in Table 1 and the characteristics of the styrene-based resin compositions shown in Tables 2 to 4 were performed by the following methods.

[0079]

<Melt mass-flow rate (MFR)>

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

[0080]

<Vicat softening temperature>

The Vicat softening temperature was measured according to JIS K 7206 at a heating rate of 50°C/hr and a test load of 50 N.

[0081]

<Content of TBC and TBX in styrene-based resin (copolymer)>

After dissolving 0.2 g of the styrene-based resin in a small amount of THF, 200 μ L of BSTFA (M,O-bis(trimethylsilyl)trifluoroacetamide) was added to perform a trimethylsilyl derivatization treatment. After adjusting the volume to 10 mL with THF, a supernatant separated by centrifugation was measured by gas chromatography-mass spectrometry (GC/MS) under the following conditions. A previously prepared calibration curve was used to determine the concentration. The TBC and TBX contained in the styrene-based resin composition can be calculated from the blending ratio of the resin used. In addition, it is possible to similarly

measure the styrene-based resin composition.

GC apparatus: 7890A manufactured by Agilent Technologies

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

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

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

Injection volume: 1 μL

MS apparatus: 5975C manufactured by Agilent Technologies

Interface temperature: 320°C

MS detection conditions: SIM measurement TBC (m/z for quantification: 295, m/z for confirmation: 310)

[0082]

<Content of phosphorus-based antioxidant (B-1) and phosphorus-phenol-based antioxidant (B-2) in styrene-based resin composition>

After completely dissolving 1.0 g of the styrene-based resin composition in 20 mL of THF, 5 mL of methanol was added dropwise, and the mixture was stirred for 20 minutes. Centrifugation was performed at 4000 rpm for 10 minutes, and the separated supernatant was measured by gas chromatography (GC) under the following conditions. A previously prepared calibration curve was used to determine the concentration.

GC apparatus: GC-2010 Plus manufactured by Shimadzu Corporation

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

Column temperature: 240°C (1 min) → (temperature increase of 10°C/min) → 320°C (15 min)

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

Injection volume: 1 μL

[0083]

<Weight average molecular weight (Mw)>

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

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

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 molecular weight in terms of polystyrene by calculating the molecular weight at each elution time from an elution curve of monodisperse polystyrene.

[0084]

<Average transmittance and YI value of styrene-based resin composition>

The average transmittance and the YI value were measured by the following procedures. Using the pellets of the styrene-based resin composition, injection molding was performed at a cylinder temperature of 190°C and a mold temperature of 40°C to mold a plate-shaped molded article having a size of 115 mm × 80 mm and a thickness of 3 mm. Next, for the obtained molded article, the spectral transmittance over a wavelength range of 350 nm to 800 nm at an optical path length of 115 mm was measured with an incident light beam having a size of 20 × 1.6 mm and a divergence angle of 0° using an ultraviolet-visible spectrophotometer V-670 manufactured by JASCO Corporation, and the YI value at a 2° field of view under a standard illuminant C was calculated in accordance with JIS K7105. The average transmittance (total light transmittance) was calculated as an average of the spectral transmittances over a wavelength range of 380 to 780 nm. Also, in order to evaluate long-term thermal stability, the obtained molded article was stored in an oven at 80°C for 1000 hours.

The article before the storage was used as an initial test light guide plate, and the article after the storage was used as a test light guide plate after a long-term durability test.

A test piece was similarly cut out from the test light guide plate after the long-term durability

test, and the YI value and the average transmittance were calculated.

[0085]

3. Production and evaluation of light guide plate

<Production of light guide plate>

The styrene-based resin composition was supplied to a single-screw vented extruder having a screw diameter of 90 mm and L/D = 32, melt-kneaded at 200 to 235°C, and then discharged from a T-die having a lip width of 800 mm and a lip opening of 3.0 mm at a T-die temperature of 245 to 250°C and a screw rotation speed of 75 rpm. After cooling and solidifying the extruded resin with three vertical cooling rolls, the end faces were trimmed to obtain a test light guide plate having a width of 600 mm and a thickness of 2.0 mm.

[0086]

<Evaluation of light guide plate>

The extrusion stability (surging), color temperature difference, and dimensional stability (hygroscopic deformation) of the test light guide plates in Tables 2 to 4 were evaluated as follows.

[0087]

<Extrusion stability (surging)>

In the production of the test light guide plate, the screw rotation speed of the extruder was gradually increased to check the screw rotation speed at which surging (discharge defects such as fluctuation in the thickness of the plate) occurred, and the extrusion stability was evaluated based on the following criteria.

A: Stable production is possible at a screw rotation speed exceeding 150 rpm.

B: Stable production is possible in a screw rotation speed range of 100 to 150 rpm.

C: Stable production is possible at a screw rotation speed of less than 100 rpm.

[0088]

<Color temperature change (long-term durability against LED light source)>

The test light guide plate was incorporated into an edge-light type lighting unit of 600 mm × 600 mm, a white LED with a color temperature of 5700 K was turned on, and the color temperature at the center portion in the plane was measured at a measuring distance of 1 m using an illuminance color meter CL-200A manufactured by Konica Minolta, Inc. (initial color temperature). Next, the lighting was continuously turned on for 5,000 hrs, the color temperature was measured by the same method (color temperature after 5,000 hrs), and the color temperature change was evaluated based on the following criteria.

Color temperature change (%) = [Initial color temperature (K) - Color temperature after 5,000 hrs (K)] / Initial color temperature (K) × 100

B: Color temperature change is less than 1%

C: Color temperature change is in a range of 1 to 5%

D: Color temperature change is more than 5%

[0089]

<Dimensional stability (hygroscopic deformation)>

A test piece of 200 mm × 300 mm was cut out from the test light guide plate, and the test piece 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 the storage was measured, and the deformation rate was calculated by the following formula.

Deformation rate = ((Long side length after storage) - (Long side length before storage)) / (Long side length before storage) × 100 (%)

The dimensional stability (hygroscopic change) of the light guide plate was evaluated by assigning B for a change rate of less than 0.10%, C for 0.10 to 0.15%, and D for more than 0.15%.

[0090]

In Examples 1 to 18, the transparency, hue, extrusion stability, long-term hue stability, and dimensional stability were good, and Examples 1 to 16 were particularly excellent including the extrusion stability and dimensional stability. In addition, Example 3 in which the hindered amine-based light stabilizer (D) was added showed a 0.2% smaller change in color temperature compared to Example 2 in which it was not added, and was more excellent in long-term durability against an LED light source.

CLAIMS

[Claim 1]

A styrene-based resin composition comprising a styrene-based resin (A) which is a copolymer comprising a styrene-based monomer unit and a (meth)acrylic acid ester-based monomer unit, an antioxidant (B), and an anthraquinone-based colorant (C), wherein:

the antioxidant (B) comprises one or both of a phosphorus-based antioxidant (B-1) and a phosphorus-phenol-based antioxidant (B-2);

the styrene-based resin composition comprises 0.001 to 0.5 parts by mass in total of the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-2) based on 100 parts by mass of the styrene-based resin (A); and

the styrene-based resin composition comprises 0.1 to 150 ppb of the anthraquinone-based colorant (C) with respect to the styrene-based resin (A).

[Claim 2]

The styrene-based resin composition of Claim 1, wherein the styrene-based resin (A) comprises 20 to 95 mass% of the styrene-based monomer unit and 5 to 80 mass% of the (meth)acrylic acid ester-based monomer unit, based on 100 mass% of the styrene-based resin (A).

[Claim 3]

The styrene-based resin composition of Claim 1, wherein the phosphorus-based antioxidant (B-1) is at least one selected from the group consisting of 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy)(2-ethylhexyloxy)phosphorus, 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, and bis(2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite.

[Claim 4]

The styrene-based resin composition of Claim 1, wherein the phosphorus-phenol-based antioxidant (B-2) is 6-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propoxy]-2,4,8,10-tetra-tert-butylidibenzo[d,f][1,3,2]dioxaphosphepin.

[Claim 5]

The styrene-based resin composition of Claim 1, wherein an average transmittance over a wavelength range of 380 to 780 nm at an optical path length of 115 mm is 85% or more, as measured using a test piece prepared by molding the styrene-based resin composition into a test piece having a size of 115 mm × 80 mm and a thickness of 3 mm.

[Claim 6]

The styrene-based resin composition of Claim 1, wherein a YI value at an optical path length of 115 mm is 4.0 or less, as measured using a test piece prepared by molding the styrene-based resin composition into a test piece having a size of 115 mm × 80 mm and a thickness of 3 mm.

[Claim 7]

An edge-light type light guide plate, which is a molded article of the styrene-based resin composition of any one of Claims 1 to 6.

[Claim 8]

An edge-light type planar light source unit comprising the edge-light type light guide plate of Claim 7 and a light source for supplying light to an end face of the light guide plate.

[Claim 9]

The edge-light type planar light source unit of Claim 7, wherein the edge-light type planar light source unit is for lighting.