

DESCRIPTION

OPTICAL STYRENE-BASED RESIN COMPOSITION, LIGHT GUIDE PLATE, AND EDGE-LIGHT-TYPE PLANAR LIGHT-SOURCE UNIT

TECHNICAL FIELD

[0001]

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

BACKGROUND

[0002]

Direct-light type backlights and edge-light type backlights can be mentioned as the type of backlights for liquid crystal displays. In the direct-light type backlights, the light source is placed at the rear of the display device, and in the edge-light type backlights, the light source is placed at the side. A component called light guide plate is used in the edge-light type backlight in order to guide the light from the light source arranged at the side of the edge-light type backlights to the entire plane 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, especially high light transmittance is required for the light guide plates. Accordingly, 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 absorbance. Further, since PMMA are prone to undergo thermal decomposition during molding, appearance of the molded body tends to degrade when molding is performed at high temperature. To solve such problems, styrene-methyl (meth)acrylate copolymer is suggested as the material of the light guide plate (for example, refer to Patent Literature 1).

On the other hand, styrene-based resin using styrene-based monomer as the raw material has low water absorbency. However, environmental variations

such as temperature and humidity can result in problems such as clouding of the molded article. In particular, when the molded article is subjected to room temperature environment from a high temperature and high humidity environment or is subjected to low temperature environment from a room temperature environment, water uniformly existing in the molded article becomes unstable, resulting in phase separation of the water. Such phenomena leads to generation of minute defects in the molded article, thereby causing clouding to occur. To solve such problem, a plate molded article comprising a styrene-based resin obtained by copolymerization of styrene-based monomer and a small amount of (meth)acrylic acid ester-based monomer is suggested (for example, refer to Patent Literature 2).

CITATION LIST

PATENT LITERATURE

[0004]

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

[Patent Literature 2] JP-A-2013-170186

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0005]

However, optical styrene-based resin composition structuring the light guide plate hardly satisfied transparency, hue, hue stability, extrusion stability, dimensional stability, clouding resistance against heat-moisture, and strength simultaneously.

[0006]

The present invention has been made by taking the afore-mentioned problems into consideration. The present invention provides a styrene-based resin composition for light guide plate which can simultaneously satisfy hue, hue stability, extrusion stability, dimensional stability, clouding resistance against heat-moisture, and strength.

SOLUTION TO PROBLEM

[0007]

According to the present invention, an optical styrene-based resin composition comprising a styrene-based resin (A) and an antioxidant (B);

wherein:

the styrene-based resin (A) is a copolymer comprising 51 to 99 mass% of styrene-based monomer unit and 1 to 49 mass% of (meth)acrylic acid ester-based monomer unit;

the antioxidant (B) contains at least one selected from the group consisting of phosphorus-based antioxidant (B-1), phenol-based antioxidant (B-2), and phosphorus-phenol-based antioxidant (B-3);

the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-3) in total are contained by 0.1 to 0.5 parts by mass with respect to 100 parts by mass of the styrene-based resin (A); and

the phenol-based antioxidant (B-2) and the phosphorus-phenol-based antioxidant (B-3) in total are contained by 0.01 to 0.5 parts by mass with respect to 100 parts by mass of the styrene-based resin (A), is provided.

[0008]

The present inventor has conducted extensive studies and have found that when the content of the styrene-based monomer unit and the (meth)acrylic acid ester-based monomer unit in the styrene-based resin and the content of the antioxidant are in a pre-determined range, the optical styrene-based resin composition can simultaneously satisfy hue, hue stability, extrusion stability, dimensional stability, clouding resistance against heat-moisture, and strength, thereby leading to completion of the present invention.

[0009]

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

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

Preferably, the phenol-based antioxidant (B-2) of the optical styrene-based resin composition is at least one selected from the group consisting of: octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate, ethylene bis(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.

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

Preferably, the content of 6-tert-butyl-2,4-xyleneol is 0.1 to 20 ppm in the optical styrene-based resin composition.

Preferably, the content of sulfur is 0.1 to 500 ppm in the optical styrene-based resin composition.

Preferably, the styrene-based resin (A) of the optical styrene-based resin composition has a weight average molecular weight (M_w) of 50,000 to 400,000, and a ratio (M_w/M_n) of the weight average molecular weight (M_w) to a number average molecular weight (M_n) of the styrene-based resin (A) is 1.0 to 3.0.

Preferably, the optical styrene-based resin composition has an initial average transmittance of 85% or more, the initial average transmittance being measured for a light having a wavelength of 380 to 780 nm with an optical path length of 115 mm.

According to another aspect of the present invention, a light guide plate obtained by molding the optical styrene-based resin composition is provided.

Preferably, the light guide plate has a thickness of 1.0 to 3.0 mm.

According to another aspect of the present invention, an edge-light-type planar light source unit comprising the light guide plate; and a light source which supplies light to an end surface of the light guide plate is provided.

MODE FOR CARRYING OUT THE INVENTION

[0010]

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

[0011]

1. styrene-based resin composition

The styrene-based resin composition according to an embodiment of the present invention is an optical styrene-based resin composition comprising a styrene-based resin (A) and an antioxidant (B).

[0012]

<styrene-based resin (A)>

The styrene-based resin (A) is a resin obtained by copolymerizing a monomer comprising styrene-based monomer and (meth)acrylic acid ester-based monomer. The styrene-based resin (A) is a copolymer comprising 51 to 99 mass% of styrene-based monomer unit and 1 to 49 mass% of (meth)acrylic acid ester-based monomer unit, preferably a copolymer comprising 51 to 85 mass% of styrene-based monomer unit and 15 to 49 mass% of (meth)acrylic acid ester-based monomer unit, and more preferably a copolymer comprising 80 to 85 mass% of styrene-based monomer unit and 15 to 20 mass% of (meth)acrylic acid ester-based monomer unit. When the content of the monomer unit is in such range, transparency, hue, hue stability, extrusion stability, dimensional stability, clouding resistance against heat-moisture, and strength can be satisfied simultaneously. In particular, by controlling the content of the styrene-based monomer unit to 99 mass% or less, a light guide plate showing low clouding by humidity and heat can be obtained. When the content of the styrene-based monomer unit is controlled to 51 % or more, a light guide plate having superior dimensional stability can be obtained. Content of the (meth)acrylic acid ester-based monomer unit in the styrene-based resin (A) is, particularly for example, 1, 5, 10, 15, 16, 17, 18, 19, 20, 25, 30, 35, 40, 45, or 50 mass%, and can be in the range between the two values exemplified herein.

[0013]

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

[0014]

As the (meth)acrylic acid ester-based monomer, for example, alkyl esters of (meth)acrylic acid such as methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, t-butyl (meth)acrylate, isoamyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, and lauryl (meth)acrylate; aryl esters of (meth)acrylic acid such as phenyl (meth)acrylate and benzyl (meth)acrylate; cycloalkyl esters of (meth)acrylic acid such as cyclohexyl (meth)acrylate, 4-t-butyl cyclohexyl (meth)acrylate, tricyclodecanyl (meth)acrylate, and adamantyl (meth)acrylate; glycidyl (meth)acrylate; and dicyclopentadienyl (meth)acrylate can be mentioned. These (meth)acrylic acid ester-based monomers can be used alone or two or more of these can be used in combination. The

(meth)acrylic acid ester-based monomer is preferably alkyl esters of (meth)acrylic acid, more preferably methyl methacrylate.

[0015]

Further, the styrene-based resin (A) can be a copolymer obtained by copolymerizing styrene-based monomer and (meth)acrylic acid ester-based monomer with a monomer which can be copolymerized therewith. As such copolymerizable monomer, for example, (meth)acrylic acids such as acrylic acid and methacrylic acid; vinyl cyanides such as acrylonitrile and methacrylonitrile; α,β -ethylene unsaturated carboxylic acids such as maleic anhydride and fumaric anhydride; and imides such as phenyl maleimide and cyclohexyl maleimide can be mentioned. These copolymerizable monomers can be used alone or two or more of these can be used in combination.

[0016]

The weight average molecular weight (M_w) of the styrene-based resin (A) is preferably 50,000 to 400,000, more preferably 100,000 to 140,000. 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 3.0, more preferably 1.5 to 2.5. When the weight average molecular weight (M_w) and the ratio (M_w/M_n) are controlled in such range, both of molding property and strength of the light guide plate can be satisfied. When the weight average molecular weight (M_w) is less than 50,000, the strength of the molded article may become 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 below 1.0, the molding property may deteriorate, and when the ratio (M_w/M_n) exceeds 3.0, the strength of the molded article may become insufficient.

[0017]

<antioxidant (B)>

Antioxidant (B) comprises at least one selected from the group consisting of phosphorus-based antioxidant (B-1), phenol-based antioxidant (B-2), and phosphorus-phenol-based antioxidant (B-3).

[0018]

The optical styrene-based resin composition contains the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-3) by total sum of 0.1 to 0.5 parts by mass with respect to 100 parts by mass of styrene-based resin (A). When the content is controlled within such range, transparency, hue, hue stability, extrusion stability, dimensional stability,

clouding resistance against heat-moisture, and strength can be satisfied simultaneously. The content of the total sum of the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-3) with respect to 100 parts by mass of styrene-based resin (A) is, particularly for example, 0.1, 0.2, 0.3, 0.4, or 0.5 parts by mass, and can be in the range between the two values exemplified herein.

[0019]

Further, the optical styrene-based resin composition contains the phenol-based antioxidant (B-2) and the phosphorus-phenol-based antioxidant (B-3) by total sum of 0.01 to 0.5 parts by mass, preferably 0.05 to 0.3 parts by mass with respect to 100 parts by mass of styrene-based resin (A). When the content is controlled within such range, transparency, hue, hue stability, extrusion stability, dimensional stability, clouding resistance against heat-moisture, and strength can be satisfied simultaneously. The content of the total sum of the phenol-based antioxidant (B-2) and the phosphorus-phenol-based antioxidant (B-3) with respect to 100 parts by mass of styrene-based resin (A) is, particularly for example, 0.01, 0.02, 0.03, 0.04, 0.05, 0.06, 0.07, 0.08, 0.09, 0.1, 0.2, 0.3, 0.4, or 0.5 parts by mass, and can be in the range between the two values exemplified herein.

[0020]

The phosphorus-based antioxidant (B-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. The phosphorus-based antioxidant (B-1) is, for example, at least one selected from the group consisting of 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy) (2-ethylhexyloxy) phosphorus, 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 of these can be used in combination.

[0021]

The phenol-based antioxidant (B-2) is an antioxidant which has a phenolic hydroxyl group within its basic skeleton and is not a phosphorous/phosphate 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, ethylene bis(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 phenol-based antioxidants can be used alone, or two or more of these can be used in combination.

[0022]

The phosphorus-phenol-based antioxidant (B-3) is a phosphorous/phosphate ester which has a phenolic hydroxyl group within its basic skeleton, and is preferably a phosphorous ester which is a trivalent phosphorus compound having phenolic hydroxyl group within its basic skeleton. The phosphorus-phenol-based antioxidant (B-3) is, for example, 6-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propoxy]-2,4,8,10-tetra-tert-butyl-dibenzo[d,f][1,3,2]dioxaphosphin.

[0023]

<other component>

The optical styrene-based resin composition contains 6-tert-butyl-2,4-xilenol (TBX) preferably by 0.1 to 20 ppm, more preferably by 1 to 5 ppm. When the content is controlled within such range, a light guide plate having superior hue and transmittance can be obtained. The content of TBX is, particularly 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 can be in the range between the two values exemplified herein.

[0024]

The optical styrene-based resin composition contains t-butylcatechol (TBC) preferably by 0.1 to 100 ppm, more preferably by 1 to 20 ppm. When the content is controlled within such range, a light guide plate having superior hue and transmittance can be obtained. The content of TBC is, particularly 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, 20, 30, 40, 50, 60, 70, 80, 90, or 100 ppm, and can be in the range between the two values exemplified herein.

[0025]

The optical styrene-based resin composition contains sulfur preferably by 0.1 to 500 ppm, more preferably by 1 to 400 ppm, and further preferably by 5 to 350 ppm. When the content is controlled within such range, a light guide plate having particularly superior hue can be obtained. The sulfur content is, particularly for example, 0.1, 0.5, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 100, 200, 300, 400, or 500 ppm, and can be in the range between the two values exemplified herein.

[0026]

The optical styrene-based resin composition can contain sulfur antioxidants; lactone antioxidants; UV absorbers; hindered amine stabilizers; antistatic agents; hydrophilic additives; bluing agents; 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 alcohols such as myristyl alcohol, cetyl alcohol, and stearyl alcohol; so long as it does not impair the characteristics of the present invention.

[0027]

<optical characteristics>

[0028]

The styrene-based resin composition preferably has an initial average transmittance of 85% or more, more preferably 86% or more, the initial average transmittance being measured for a light having a wavelength of 380 to 780 nm with an optical path length of 115 mm.

[0029]

The styrene-based resin composition after long-term durability test preferably has an average transmittance of 80% or more, more preferably 83% or more, and further preferably 85% or more, the average transmittance being measured for a light having a wavelength of 380 to 780 nm with an optical path length of 115 mm.

[0030]

The styrene-based resin composition preferably has an initial YI value of 6.0 or lower, more preferably 4.0 or lower, the YI value being measured for an optical path length of 115 mm.

[0031]

The styrene-based resin composition after long-term durability test preferably has a YI value of 7.0 or lower, more preferably 5.0 or lower, the YI value being measured with an optical path length of 115 mm.

[0032]

The difference between the YI value (Δ YI), that is, difference between the initial YI value measured with an optical path length of 115 mm and the YI value measured after long-term durability test with an optical path length of 115 mm is preferably 3.0 or less, more preferably 1.5 or less, and further preferably 1.0 or less.

[0033]

<others>

The Vicat softening temperature of the styrene-based resin composition is preferably 95 to 104°C, more preferably 100 to 104°C. When the Vicat softening temperature is below 95°C, heat resistance would be insufficient, and the light guide plate can undergo deformation depending on the usage environment. [0034]

<manufacturing method of styrene-based resin composition>

As the polymerization method of the styrene-based resin (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 it is preferable that these methods are continuous polymerization. As the solvent, alkylbenzene such as benzene, toluene, ethylbenzene, and xylene; ketone such as acetone and methyl ethyl ketone; and aliphatic hydrocarbon such as hexane and cyclohexane can be used. [0035]

When the styrene-based resin (A) is polymerized, 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. Known radical polymerization initiator, for example, peroxyketal 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; hydroperoxide such as cumene hydroperoxide and t-butyl hydroperoxide; alkyl peroxide such as t-butyl peroxyacetate and t-amyl peroxyisooctanoate; dialkyl peroxide such as t-butyl cumyl peroxide, di-t-butyl peroxide, dicumyl peroxide, and di-t-hexyl peroxide; peroxy ester such as t-butyl peroxyacetate, t-butyl peroxy benzoyate, and t-butyl peroxy isopropyl monocarbonate; peroxy carbonate such as t-butyl peroxy isopropyl carbonate and polyether tetrakis(t-butyl peroxy carbonate); N,N'-azobis(cyclohexane-1-carbonitrile), N,N'-azobis(2-methylbutyronitrile), N,N'-azobis(2,4-dimethylvaleronitrile), N,N'-azobis[2-(hydroxymethyl)propionitrile] and the like can be mentioned. These polymerization initiators can be used alone, or two or more of these can be used in combination. As the chain transfer agents, 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 can be mentioned. Among these, from the viewpoint of the ability to adjust sulfur content, aliphatic mercaptans, aromatic mercaptans, thiocarboxylic acids, and polyfunctional mercaptans are preferable.

[0036]

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

[0037]

First, in the polymerization step, conventional complete stirred tank-type agitation tank or column reactor are 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.

[0038]

The polymerization solution containing the polymer after the polymerization step is transferred to the devolatilization step, and the unreacted monomer and the polymerization solvent are removed. The devolatilization step comprises 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 cut method, air-cooled hot cutting method or underwater hot cutting method.

[0039]

The styrene-based resin composition can be manufactured by adding antioxidant (B) to styrene-based resin (A). The antioxidant (B) can be added when polymerization of the styrene-based resin (A) is performed, or the antioxidant (B) can be dry blended after polymerization of the styrene-based resin (A), followed by melting and kneading. Further, manufacture can be carried out also by melting and kneading the antioxidant (B) with a small amount of styrene-based resin before-hand to obtain a pellet master batch, and then dry blending the master batch with the styrene-based resin (A) followed by melting and kneading.

[0040]

The content of t-butylcatechol or 6-tert-butyl-2,4-xyleneol and the sulfur content in the 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. The content can be adjusted by adding them at an arbitrary timing.

[0041]

2. light guide plate

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

[0042]

<shape of light guide plate>

The light guide plate can 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 portion of lenticular shape and/or 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 can be provided on other surfaces if necessary. However, it is preferable to provide the convex portion only on the front surface (light emitting surface) of the light guide plate.

[0043]

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

[0044]

The thickness of the light guide plate is 1.0 to 3.0 mm, more preferably 1.5 to 2.5 mm, and further preferably 1.6 to 2.4 mm. When the thickness is controlled within such range, a light guide plate having superior molding property such as extrusion stability and strength can be easily manufactured by molding the styrene-based resin composition added with the antioxidant.

[0045]

<manufacturing method of light guide plate>

A light guide plate according to an embodiment of the present invention can be obtained by molding the afore-mentioned styrene-based resin composition. As the molding method, known methods such as sheet extrusion molding, injection molding, and compression molding can be used. Here, 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. As an example of the sheet extrusion molding, a continuous sheet extrusion molding method comprising 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 being adhered to the cooling roll; wherein the surface of the cooling roll is provided with a transfer mold. By altering the shape of the transfer mold, arbitrary concave-convex shape can be transferred onto the surface of sheet.

[0046]

Further, the light guide plate can be provided with a concave-convex shape at the front surface (light emitting surface) thereof, and a reflective processing at the rear surface thereof to diffuse the light. As the reflective processing, for example, silk printing and inkjet printing, as well as laser irradiation to provide dot-shaped roughness can be mentioned. When printing a dot pattern, an ink including fine particles which can diffuse light can be used.

[0047]

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 afore-mentioned light guide plate and a light source which supplies 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.

EXAMPLE

[0048]

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

[0049]

1. manufacture of styrene-based resin A-1 to A-11

First reactor which is a complete stirred agitation tank and a second reactor which is a plug flow reactor with static mixer were connected in series to constitute a polymerization step. Manufacture of styrene-based resin was performed in accordance with the conditions shown in Table 1. Volume of each of the reactors were set as 30 liters for the first reactor and 12 liters for the second reactor. Raw material solution was prepared with the raw material composition shown in Table 1, and the raw material solution was continuously supplied to the first reactor with the flow rate shown in Table 1. The polymerization initiator was added to the raw material solution and mixed uniformly so that the addition concentration (concentration based on the mass of the raw material styrene) at the inlet of the first reactor would satisfy the value shown in Table 1. The raw materials shown in Table 1 are as follows.

polymerization initiator: t-butyl peroxy isopropyl monocarbonate (perbutyl I, available from NOF CORPORATION)

chain transfer agent: n-dodecyl mercaptan (available from Arkema)

In the second reactor, temperature gradient was provided in the direction of the flow of the reaction solution. Temperature was adjusted so as to satisfy the temperatures at the middle portion and exit portion as shown in Table 1.

Subsequently, the solution including the polymer taken out continuously from the second reactor was 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 shown in Table 1 was satisfied and the pressure was adjusted to the pressure shown in Table 1 to separate unreacted styrene and ethylbenzene. Thereafter, the polymer was extruded into strands from a porous die, and the strand was cooled and cut into pellets by cold cut method.

[0050]

<melt mass flow rate (MFR)>

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

[0051]

<Vicat softening temperature>

Vicat softening temperature was measured in accordance with JIS K 7206 under conditions of 50 °C/hr programming rate and 50 N evaluation load.

[0052]

<sulfur content>

Ion chromatograph (DX-120, available from Nippon Dionex K.K.) was used

to perform combustion chromatography method under the following measuring conditions.

combustion pretreatment equipment: AQF-100, WS100, GA-100 (available from Mitsubishi Chemical Corporation)

amount of sample: 100 mg

temperature of combustion tube: inlet 900 °C, outlet 1000 °C

absorbing liquid: 600 mg/L H₂O₂ + 10 mg/L PO₄³⁻ (internal standard)

amount of absorbing liquid: 5 mL

detector: conductivity detector

column: AS12A

flow rate: 1.5 mL/min

mobile phase: 2.7 mM Na₂CO₃ + 0.3 mM NaHCO₃

amount of introduced sample: 20 µL

[0053]

<content of TBC and TBX in styrene-based resin>

After dissolving 0.2 g of styrene-based resin in a small amount of THF, 200 µL of BSTFA (M,O-bis(trimethylsilyl)(trifluoro acetamide) was added to perform trimethylsilyl-derivatization treatment. Subsequently, 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, concentration was determined with a calibration curve prepared in advance.

GC Instrument: 7890A, available from Agilent Technologies

Column: DB-5ms (0.25 mm i.d. x 30 m), liquid phase film thickness 0.25 µm, available from 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 Instrument: 5975C, available from Agilent Technologies

Interface temperature: 320 °C

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

[0054]

<molecular weight>

Weight average molecular weight (M_w), Z average molecular weight (M_z), and number average molecular weight (M_n), were measured using gel permeation chromatography (GPC) with the following conditions.

GPC Instrument: Shodex GPC-101, available from Showa Denko K.K.

Column: PLgel 10 μ m MIXED-B, available from 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

Molecular weight is calculated as polystyrene equivalent molecular weight obtained for each of the elution time of the elution curve of monodisperse polystyrene.

[Table 1]

Table 1	condition 1	condition 2	condition 3	condition 4	condition 5	condition 6	condition 7	condition 8	condition 9	condition 10	condition 11
name of resin	A-1	A-2	A-3	A-4	A-5	A-6	A-7	A-8	A-9	A-10	A-11
amount of raw material supplied	kg/hr	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0	8.0
raw material	styrene	75.5	77.0	86.5	65.5	53.0	49.0	22.0	90.0	75.0	76.0
composition	methyl methacrylate	14.5	13.0	6.5	24.5	37.0	41.0	66.0	-	15.0	14.0
	ethyl benzene	10.0	10.0	10.0	10.0	10.0	10.0	12.0	10.0	10.0	10.0
polymerization initiator	ppm *1	150	150	200	200	150	150	100	250	150	150
chain transfer agent	ppm *1	100	100	100	100	300	500	3000	0	0	3000
reaction temp.	first reactor	140	140	135	135	140	135	130	130	140	130
	second reactor (middle portion)	135	140	135	135	130	130	130	135	140	130
	second reactor (exit portion)	150	160	160	160	150	145	145	150	165	150
devolatilization tank	resin temperature	240	240	240	240	240	240	240	240	240	240
	pressure	kPa	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
	styrene unit	mass%	80	82	91	95	50	25	100	80	80
resin property	methyl methacrylate unit (MMA unit amount)	mass%	20	18	9	5	50	75	0	20	20
	Mn	$\times 10^4$	12.0	11.7	12.3	12.5	8.3	5.8	12.1	12.3	11.0
	Mw	$\times 10^4$	25.0	24.0	26.9	27.1	14.5	10.2	28.5	25.3	23.0
	Mz	$\times 10^4$	39.6	38.9	43.0	43.7	22.5	16.1	53.0	40.7	36.5
	Mw/Mn	-	2.08	2.05	2.19	2.17	1.75	1.76	2.36	2.06	2.09
	Mz/Mw	-	1.58	1.62	1.60	1.61	1.55	1.58	1.86	1.61	1.59
	melt mass flow rate	g/10min	2.2	2.1	2.0	2.0	2.2	1.8	2.5	2.1	2.5
	Vicat softening temperature	°C	102	103	103	103	102	103	103	102	102
	sulfur content	ppm	9.8	9.0	9.7	9.5	64	325	0	0	340
	amount of TBC in styrene-based resin	ppm	3.2	3.4	4.0	4.2	1.9	1.1	4.5	3.2	3.2
	amount of TBX in styrene-based resin	ppm	0.4	0.4	0.4	0.3	0.7	1.2	0	0.4	0.4

*1 concentration based on mass with respect to total monomer

[0055]

2. manufacture of styrene-based resin composition

[Example 1]

To 100 parts by mass of pelletized styrene-based resin (A-1), 0.2 parts by mass of phosphorus-based antioxidant (HP-10) and 0.1 parts by mass of phosphorus-phenol-based antioxidant (GP) were added and mixed using a blender. The mixture was further mixed using a single-screw extruder having a screw diameter of 40 mm under 230°C of screw temperature and 100 rpm of screw rotation number, thereby obtaining the styrene-based resin composition.

[0056]

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

Styrene-based resin composition and light guide plate were manufactured in a similar manner as Example 1, except for altering the formulations as shown in Tables 2 to 4. Results of various measurements and evaluations are shown in Tables 2 to 4.

[0057]

Here, phosphorus-based antioxidant (B-1), phenol-based antioxidant (B-2), and phosphorus-phenol-based antioxidant (B-3) mentioned in Tables 2 to 4 are each as follows.

[0058]

(phosphorus-based antioxidant (B-1))

HP-10: 2,2'-methylenebis(4,6-di-tert-butyl-1-phenyloxy) (2-ethylhexyloxy) phosphorus (ADK STAB HP-10, available from ADEKA Corporation)

168: tris(2,4-di-tert-butylphenyl) phosphite (Irgafos 168, available from BASF Japan, Ltd.)

PEP-36: 3,9-bis(2,6-di-tert-butyl-4-methylphenoxy)-2,4,8,10-tetraoxa-3,9-diphosphaspiro[5,5] undecane (ADK STAB PEP-36, available from ADEKA Corporation)

P-EPQ: tetrakis (2,4-di-tert-butylphenyl) [1,1-biphenyl]-4,4 diyl bisphosphonate (Hostanox P-EPQ, available from Clariant Co., Ltd.)

38: bis(2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite (Irgafos 38, available from BASF Japan, Ltd.)

[0059]

(phenol-based antioxidant (B-2))

1076: octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate (Irganox 1076, available from BASF Japan, Ltd.)

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

1010: pentaerythritol tetrakis [3-(3,5-di-tert-butyl-4-hydroxyphenyl)propionate] (Irganox 1010, available from BASF Japan, Ltd.)

A080: 3,9-bis{2-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propionyloxy]-1,1-dimethylethyl}-2,4,8,10-tetraoxaspiro[5,5] undecane (ADK STAB A0-80, available from ADEKA Corporation)

[0060]

(phosphorus-phenol-based antioxidant (B-3))

GP: 6-[3-(3-tert-butyl-4-hydroxy-5-methylphenyl)propoxy]-2,4,8,10-tetra-tert-butyl-dibenzo[d,f][1,3,2] dioxaphosphin (Sumilizer GP, available from SUMITOMO CHEMICAL COMPANY, LIMITED)

[0061]

[Table 2]

Table 2			Example									
resin composition	formulation		1	2	3	4	5	6	7	8	9	10
			A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1
styrene-based resin (A)	type	—	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1	A-1
	amount of MMA unit	mass%	20	20	20	20	20	20	20	20	20	20
	amount of addition	parts by mass	100	100	100	100	100	100	100	100	100	100
	phosphorus-based antioxidant (B-1)	—	HP-10	168	PEP-36	P-EPQ	38	168	168	168	168	HP-10
	amount of addition	parts by mass	0.1	0.2	0.2	0.2	0.2	0.3	0.2	0.2	0.2	0.2
	type	—	—	—	—	—	—	1076	245	1010	AO80	1076
	amount of addition	parts by mass	0	0	0	0	0	0.05	0.05	0.02	0.05	0.1
	phenol-based antioxidant (B-2)	—	GP	GP	GP	GP	GP	—	—	—	—	—
	phosphorus-phenol-based antioxidant (B-3)	—	GP	GP	GP	GP	GP	—	—	—	—	—
	amount of addition	parts by mass	0.1	0.1	0.1	0.1	0.1	0	0	0	0	0
composition	total content of B-1 and B-3	parts by mass	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2
	total content of B-2 and B-3	parts by mass	0.1	0.1	0.1	0.1	0.1	0.05	0.05	0.02	0.05	0.1
	content of sulfur	ppm	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8	9.8
	content of TBC	ppm	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2	3.2
	content of TBX	ppm	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4	0.4
	average transmittance	%	87	86	86	86	86	86	86	86	86	87
	Y1 value	—	3.2	3.0	2.9	3.4	3.2	3.5	3.3	3.4	3.2	3.0
	average transmittance	%	85	85	85	85	85	85	85	85	85	85
	Y1 value	—	4.0	3.8	3.9	4.3	4.3	4.4	4.3	4.4	4.2	3.8
	$\Delta Y1$	—	0.8	0.8	1.0	0.9	1.1	0.9	1.0	1.0	1.0	0.8
optical property of resin composition	extrusion stability (eye mucus)	—	A	A	A	A	A	A	A	A	A	A
	dimensional stability (deformation due to moisture absorption)	—	A	A	A	A	A	A	A	A	A	A
	clouding resistance against heat-moisture	—	A	A	A	A	A	A	A	A	A	A
	strength	—	A	A	A	A	A	A	A	A	A	A

[0062]

[Table 3]

Table 3				Example													
				11	12	13	14	15	16	17	18						
resin composition	formulation	styrene-based resin (A)	type	—													
			amount of MMA unit	mass%	20	18	9	5	32	45	20	20					
			amount of addition	parts by mass	100	100	100	100	100	100	100	100					
		phosphorus-based antioxidant (B-1)	type	—													
			amount of addition	parts by mass	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.1	0.1			
			type	—	1076	—	—	—	—	—	—	—	—	—			
		phenol-based antioxidant (B-2)	amount of addition	parts by mass	0.1	0	0	0	0	0	0	0	0	0			
			phosphorus-phenol-based antioxidant (B-3)	type	—												
				amount of addition	parts by mass	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1		
	composition		total content of B-1 and B-3	parts by mass	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.2	0.2			
			total content of B-2 and B-3	parts by mass	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1			
			content of sulfur	ppm	9.8	9.0	9.7	9.5	37	65	0	339					
			content of TBC	ppm	3.2	3.4	4.0	4.2	2.5	2.0	3.2	3.2					
			content of TBX	ppm	0.4	0.4	0.4	0.3	0.6	0.7	0.4	0.4					
optical property of resin composition		initial	average transmittance	%	87	86	86	86	87	87	87	87					
		after long-term durability test (80°C/1,000h)	YI value	—	3.0	3.2	3.5	3.8	2.5	2.2	4.2	2.5					
			average transmittance	%	86	85	85	85	86	86	86	86					
			YI value	—	3.5	3.7	4.5	4.8	3.5	3.0	5.2	3.1					
			Δ YI	—	0.5	0.5	1.0	1.0	1.0	0.8	1.0	0.6					
property of light guide plate		extrusion stability (eye mucus)	—	A	A	A	A	A	A	A	A	A	A				
		dimensional stability (deformation due to moisture absorption)	—	A	A	A	A	A	A	A	A	A	A				
		clouding resistance against heat-moisture	—	A	A	B	B	A	A	A	A	A	A				
		strength	—	A	A	A	A	A	A	A	A	A	A				

[0063]

[Table 4]

Table 4			Comparative Example							
			1	2	3	4	5	6	7	8
resin composition	formulation	styrene-based resin (A)	type	A-1	A-2	A-3	A-4	A-7	A-8	A-9
			amount of MMA unit	20	18	9	5	50	75	0
		phosphorus-based antioxidant (B-1)	amount of addition	100	100	100	100	100	100	100
			type	168	168	168	—	38	38	168
		phenol-based antioxidant (B-2)	amount of addition	0.02	0.6	0.02	0	0.02	0.02	0.05
			type	—	—	—	—	—	—	—
		phosphorus-phenol-based antioxidant (B-3)	amount of addition	0	0	0	0	0	0	0
			type	GP	GP	GP	—	GP	GP	GP
	composition	total content of B-1 and B-3	amount of addition	0.05	0.3	0.05	0	0	0.05	0.1
			parts by mass	0.07	0.9	0.07	0	0	0.07	0.15
		total content of B-2 and B-3	parts by mass	0.05	0.3	0.05	0	0	0.05	0.1
			content of sulfur	9.8	9.7	9.0	9.7	9.5	64	325
		content of TBC	ppm	3.2	3.2	3.4	4.0	4.2	1.9	1.1
			content of TBX	0.4	0.4	0.4	0.4	0.3	0.7	1.2
optical property of resin composition	initial	average transmittance	ppm	86	86	86	86	88	90	84
			%	3.0	4.5	4.8	3.9	4.0	2.2	2.0
		average transmittance	YI value	85	86	85	83	85	88	83
			YI value	7.0	6.0	7.8	8.9	9.2	5.0	3.5
		after long-term durability test (80°C/1,000h)	ΔYI	4.0	1.5	3.0	5.0	5.2	2.0	1.5
			extrusion stability (eye mucus)	C	A	C	C	C	B	A
property of light guide plate	dimensional stability (deformation due to moisture absorption)	clouding resistance against heat-moisture	—	A	A	A	A	A	B	C
			—	A	A	A	A	B	A	C
		strength	—	B	B	B	B	C	B	A

[0064]

3. evaluation

Content of TBC, TBX, and sulfur shown in Tables 2 to 4 are calculated values based on the content of TBC, TBX, and sulfur in the styrene-based resin used.

[0065]

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

Average transmittance and YI value were measured in accordance with the following procedures. Pellets of the styrene-based resin composition were used to perform injection molding under conditions of 230 °C cylinder temperature and 50 °C mold temperature, thereby molding a plate-shaped molded article (initial sample) having a size of 127 x 127 x 3 mm thickness.

Samples for evaluating long-term durability (samples after long-term durability test) were stored in an oven at 80 °C for 1000 hours.

Subsequently, test specimens having a size of 115 x 85 x 3 mm thickness were cut out from plate-shaped molded articles of initial samples and samples after long-term durability test. The edge of the cut-out test samples were subjected to a buffing process to prepare plate-shaped molded articles having mirrored face at its edge. The buffed plate-shaped molded articles were then subjected to measurement of spectral transmittance for a light having a wavelength of 350 nm to 800 nm with optical path length of 115 mm, using ultraviolet-visible spectrophotometer V-670 available from JASCO Corporation with a slit size of 20 x 1.6 mm to emit an incident light having a widening angle of 0 °C. Subsequently, YI value for C light source with visual field of 2 °C was calculated in accordance with JIS K7105. The average transmittance (total light transmittance) was calculated as an average of spectral transmittance within the wavelength of 380 to 780 nm.

[0066]

<manufacture of light guide plate>

The 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 and kneaded at 200 to 235 °C, followed by ejection 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 ejected resin composition was cooled and solidified using a vertical arranged three roll mill, and then the end face was trimmed to obtain a light guide plate with a width of 800 mm and a thickness of 2.0 mm.

[0067]

<evaluation of molding property and strength of light guide plate>

Extrusion stability (eye mucus), dimensional stability (deformation due to moisture absorption), clouding resistance against heat-moisture, and strength of the light guide plate shown in Tables 2 to 4 were evaluated as follows.

[0068]

(extrusion stability (eye mucus))

The temperature of resin flowing through the die was adjusted to 300°C, and generation of eye mucus near the die was evaluated in accordance with the following criteria.

A: No eye mucus is observed even after more than 30 minutes from the starting of the sheet extrusion.

B: Eye mucus is observed after more than 10 minutes to at or before 30 minutes from the starting of the sheet extrusion.

C: Eye mucus is observed before at or before 10 minutes from the starting of the sheet extrusion.

Here, "eye mucus" is a deteriorated brown or black resin generated around the exit nozzle of a die. Usually, the amount of the eye mucus increases as the amount of extrusion increases. When the amount of the eye mucus reaches a certain amount, it detaches from the nozzle and adheres on the sheet surface.

[0069]

(dimensional stability (deformation due to moisture absorption))

A test specimen having a size of 200 mm x 300 mm was cut out from the light guide plate thus obtained. The test specimen was stored under conditions of 60 °C and relative humidity of 90% for 500 hours. Length of the long side of the test specimen before and after storage were measured, and the deformation rate was calculated with the following equation.

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

Dimensional stability (deformation due to moisture absorption) of the light guide plate was evaluated as follows. Dimensional stability was evaluated as "A" when the specimen had the deformation rate of 0.10% or lower, evaluated as "B" when the specimen had the deformation rate of higher than 0.10% and lower than 0.15%, and evaluated as "C" when the specimen had the deformation rate of 0.15% or higher.

[0070]

(clouding resistance against heat-moisture)

A test specimen having a size of 200 mm x 200 mm was cut out from the light guide plate thus obtained. The test specimen was stored under conditions of 60 °C and relative humidity of 90% for 150 hours. Subsequently, the test specimen was taken out and placed under conditions of 23 °C and relative humidity of 50%, thereby cooling the test specimen rapidly. The test specimen was further allowed to stand in such conditions for 1 hour. The test specimen was observed to see whether whitening had generated inside the test specimen. Evaluation of clouding resistance against heat-moisture was performed in accordance with the following criteria.

A: No whitening generated.

B: Scarce whitening generated, but mostly vanishes after 24 hours.

C: Severe whitening generated, and remains after 24 hours.

[0071]

(strength)

A test specimen having a size of 200 mm x 200 mm was cut out from the light guide plate thus obtained. A ball of 16.6 g weight was used to measure 50 % impact-failure height in accordance with JIS K-7211. Strength of the light guide plate was evaluated as "A" when the 50 % impact-failure height was 50 cm or higher, evaluated as "B" when the 50 % impact-failure height was higher than 30 cm and lower than 50 cm, and was evaluated as "C" when the 50 % impact-failure height was 30 cm or lower.

[0072]

In the Examples, transparency, hue, hue stability, extrusion stability, dimensional stability, clouding resistance against heat-moisture, and strength were superior. Particularly, Examples 1 to 12 and Examples 15 to 18 showed especially superior properties including clouding resistance against heat-moisture.

In Examples 1 to 16 and Example 18 which had sulfur content of 0.1 to 500 ppm, hue was especially superior.

CLAIMS

1. An optical styrene-based resin composition comprising a styrene-based resin (A) and an antioxidant (B); wherein:

the styrene-based resin (A) is a copolymer comprising 51 to 99 mass% of styrene-based monomer unit and 1 to 49 mass% of (meth)acrylic acid ester-based monomer unit;

the antioxidant (B) contains at least one selected from the group consisting of phosphorus-based antioxidant (B-1), phenol-based antioxidant (B-2), and phosphorus-phenol-based antioxidant (B-3);

the phosphorus-based antioxidant (B-1) and the phosphorus-phenol-based antioxidant (B-3) in total are contained by 0.1 to 0.5 parts by mass with respect to 100 parts by mass of the styrene-based resin (A); and

the phenol-based antioxidant (B-2) and the phosphorus-phenol-based antioxidant (B-3) in total are contained by 0.01 to 0.5 parts by mass 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 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, 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.

3. The optical styrene-based resin composition of Claim 1 or 2, wherein the phenol-based antioxidant (B-2) is at least one selected from the group consisting of: octadecyl-3-(3,5-di-tert-butyl-4-hydroxyphenyl) propionate, ethylene bis(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.

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

5. The optical styrene-based resin composition of any one of Claims 1 to 4, wherein a content of 6-tert-butyl-2,4-xyleneol is 0.1 to 20 ppm.
6. The optical styrene-based resin composition of any one of Claims 1 to 5, wherein a content of sulfur is 0.1 to 500 ppm.
7. The optical styrene-based resin composition of any one of Claims 1 to 6; wherein:
 - the styrene-based resin (A) has a weight average molecular weight (M_w) of 50,000 to 400,000; and
 - a ratio (M_w/M_n) of the weight average molecular weight (M_w) to a number average molecular weight (M_n) of the styrene-based resin (A) is 1.0 to 3.0.
8. The optical styrene-based resin composition of any one of Claims 1 to 7; wherein:
 - the optical styrene-based resin composition has an initial average transmittance of 85% or more, the initial average transmittance being measured for a light having a wavelength of 380 to 780 nm with an optical path length of 115 mm.
9. A light guide plate obtained by molding the optical styrene-based resin composition of any one of Claims 1 to 8.
10. The light guide plate of Claim 9, wherein the light guide plate has a thickness of 1.0 to 3.0 mm.
11. An edge-light-type planar light source unit comprising:
 - the light guide plate of Claim 9 or 10; and
 - a light source which supplies light to an end surface of the light guide plate.