

DESCRIPTION**Title of Invention**

EDGE-LIGHT-TYPE LIGHT GUIDE PLATE AND EDGE-LIGHT-TYPE SURFACE LIGHT SOURCE UNIT

Technical Field

[0001]

The present invention relates to an edge light-type light guide plate and an edge light-type surface light source unit.

Background Art

[0002]

There are two types of backlights for liquid crystal displays: the direct-light-type, where the light source is placed in front of the display unit, and the edge-light-type, where the light source is placed on the side of the display unit. A light guide plate is incorporated in the edge light-type backlight and plays the role of guiding the light from the side to the liquid crystal panel, and is used in a wide range of applications such as TVs, desktop personal computer monitors, notebook personal computers, mobile phones, and car navigation systems. The backlight using the light guide plate is also used for lighting. It has been proposed to use a styrene-based resin for the light guide plate, which has lower water absorption than an acrylic resin represented by PMMA (polymethyl methacrylate), and thus, the molded article thereof is less likely to warp or change in size (Patent Literature 1). It has also been proposed to use polystyrene for the light guide plate.

[0003]

The light guide plate is a member that has the function of receiving light from the end surface (side surface) of the plate-shaped molded article, guiding the light to the front surface (light emitting surface) of the molded article by a reflection pattern formed on the rear surface (non-light emitting surface) of the molded article and emitting the light from the surface. In recent years, the light guide plate has tended to be large and thin. In order to improve the uniformity of the emitted light, it has become an industrial mainstream to provide a prism pattern or the like on the front surface (light emitting surface) of the plate-shaped molded article. The pattern on the front surface or the rear surface of the plate-shaped molded article can be formed at the same time as molding the plate-shaped molded article. For example, the pattern can be formed by a mold shape in an injection molding, roll transfer in an extrusion molding, or the like.

Citation List**Patent Literature**

[0004]

Patent Literature 1 JP 2003-075648

Patent Literature 2 WO2013/094642

Summary of Invention**Technical Problem**

[0005]

However, in a light guide plate using polystyrene, which is inferior in optical properties to acrylic resin, the moldability of the pattern is a big problem. When a concave-convex pattern is provided on the front surface (light emitting surface) of the light guide plate, the pattern may be formed by roll transfer in extrusion molding.

However, in molding, there are problems such as occurrence of die drool (granular products of resin near an outlet of a T-die extruder during sheet molding) and poor transferability and releasability. It was difficult to easily produce a light guide plate giving uniform brightness. When the pattern forming is insufficient, there is a problem that not only the optical properties are inferior, but also the strength is low in combination with the thinning, and the light guide plate cannot be put into practical use.

[0006]

The present invention has been made in view of such a problem and provides an edge light-type light guide plate, which has excellent brightness uniformity and can be easily manufactured due to excellent moldability in producing the light guide plate by an extrusion molding and a roll transfer, and an edge light-type surface light source unit using the light guide plate.

Solution to Problem

[0007]

According to the present invention, an edge light-type light guide plate containing a styrene-based resin composition, wherein:

a surface of the edge light-type light guide plate has a plurality of lenticular-shaped and/or prism-shaped convex portions;

a thickness T of the edge light-type light guide plate is 1.0 to 3.0 mm;

the styrene-based resin composition comprises a styrene-based resin and a phosphorus-based antioxidant (A) and/or a phenol-based antioxidant (B); and

at least one of the following conditions (1) and (2) is satisfied:

(1) a height H of the convex portions is 10 to 500 μm ;

(2) a pitch P between the convex portions is 30 to 800 μm

is provided.

[0008]

As a result of intensive studies, the present inventors have found that in an edge light-type light guide plate comprising a styrene-based resin composition, when the surface of the edge light-type light guide plate has a predetermined pattern of a plurality of lenticular-shaped and/or prism-shaped convex portions, the thickness of the styrene-based resin composition is within a predetermined range and the styrene-based resin composition comprises a specific antioxidant, the edge light-type light guide plate has excellent brightness uniformity and can be easily produced due to excellent moldability, completing the present invention.

[0009]

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

Preferably, the height H of the convex portions is 10 to 500 μm , and the pitch P between the convex portions is 30 to 800 μm .

Preferably, the edge light-type light guide plate of comprises 0.001 to 0.5 parts by mass of the phosphorus-based antioxidant (A) and 0.001 to 0.5 parts by mass of the phenol-based antioxidant (B) with respect to 100 parts by mass of the styrene-based resin composition.

Preferably, the phosphorus-based antioxidant (A) is at least one selected from a 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 diylbiphosphonite, bis (2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite ester.

Preferably, the phenol-based antioxidant (B) is at least one selected from a group consisting of 6- [3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propoxy] -2,4,8,10-tetra-tert-butyl-dibenzo [d, f] [1,3,2] dioxaphosphine, 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], 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, a weight average molecular weight (Mw) of the styrene-based resin is 200,000 to 400,000, and a ratio (Mw/Mn) of the weight average molecular weight (Mw) to a number average molecular weight (Mn) of the styrene-based resin is 1.0 to 3.0.

Preferably, the styrene-based resin composition has an initial average transmittance of 80% or more at a wavelength of 380 to 780 nm in an optical path length of 115 mm.

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

Brief Description of the Drawings

[0010]

Fig.1 is a perspective view showing an outline of a light guide plate of the present invention. Fig. 1A is a perspective view when a convex portion is lenticular-shaped, and Fig. 1B is a perspective view when a convex portion is prism-shaped.

Fig.2 is a cross-sectional view of a light guide plate of the present invention. Fig. 2A is a cross-sectional view when a convex portion is lenticular-shaped, and Fig. 2B is a cross-sectional view when a convex portion is prism-shaped.

Fig.3 is a schematic view showing one example of a method of producing a light guide plate of the present invention.

Description of Embodiments

[0011]

Hereinafter, embodiments of the present invention will be described. The various features shown in the embodiments shown below can be combined with each other. In addition, the invention is independently established for each feature.

[0012]

1. Edge light-type light guide plate

[Shape of light guide plate]

(Convex portion)

The edge light-type light guide plate of the present invention has concave-convex shapes on the surface of the light guide plate. More specifically, as shown in Fig. 1, the surface of the light guide plate 1 has a plurality

of lenticular-shaped (Fig. 1A) and/or prism-shaped (Fig. 1B) convex portions 3. The convex portion is preferably provided on at least one surface of the light guide plate and particularly needs to be provided on one surface which is the front surface (light emitting surface) of the light guide plate. The convex portion is provided on other surfaces may be provided if necessary, but it is more preferable that the convex portion is provided only on the front surface (light emitting surface) of the light guide plate.

[0013]

Here, the lenticular-shaped convex portion is an arc-shaped convex portion 3A as shown in Fig. 1A, and the edge shape of the cross section is an arc-shaped ridge (Fig. 2A). The prism shape is an arc-shaped convex portion 3B as shown in Fig. 1B, and the edge shape of the cross section is a triangular chevron-shaped ridge (Fig. 2B). Further, the convex portions are formed by a plurality of ridges, which are formed so as to be in a parallel with each other (Fig. 1). Further, it is preferable that the convex portions are integrally formed with the light guide plate.

[0014]

The plurality of convex portions on the surface of the light guide plate are not limited as long as the plurality of convex portions are formed but are preferably formed in a periodic pattern.

[0015]

The pitch P between the convex portions is preferably 30 to 800 μm , more preferably 100 to 600 μm , and further preferably 200 to 400 μm . Within such a range, it is easy to mold a styrene-based resin composition, to which an antioxidant is added, with excellent extrusion stability, roll transferability, and roll releasability to produce a light guide plate having sufficient strength. Specifically, the pitch P between the convex portions is, for example, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650., 700, 750, 800 μm , and may be within the range between any two of the numerical values exemplified here. Here, the pitch P between the convex portions is an average value of the distances between the vertices of the adjacent convex portions, as shown in Fig 2. In one specific example, it is the average value of the distances between the vertices of adjacent convex portions for 100 consecutive convex portions in an arbitrary range.

[0016]

The height H of the convex portion is preferably 10 to 500 μm , more preferably 50 to 300 μm , and further preferably 90 to 200 μm . Within such a range, it is easy to mold a styrene-based resin composition, to which an antioxidant is added, with excellent extrusion stability, roll transferability, and roll releasability to produce a light guide plate having sufficient strength. Specifically, the height H of the convex portion is, for example, 10, 20, 21, 25, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 350, 400, 450, 500 μm , and may be within the range between any two of the numerical values exemplified here. Here, the height H of the convex portion is, as shown in Fig. 2, the average value of the difference between the lowest portion and the highest portion of the convex portion. In one specific example, it is the average value of the difference between the lowest portion and the highest portion of the convex portion for 100 continuous convex portions in an arbitrary range.

[0017]

The width W of the convex portion is preferably 30 to 800 μm , more preferably 100 to 600 μm , and further preferably 200 to 400 μm . Within such a range, it is easy to mold a styrene-based resin composition, to which an antioxidant is added, with excellent extrusion stability, roll transferability, and roll releasability to produce

a light guide plate having sufficient strength. Specifically, the width W of the convex portion is, for example, 30, 40, 50, 60, 70, 80, 90, 100, 150, 200, 250, 300, 350, 400, 450, 500, 550, 600, 650, 700, 750, 800 μm , and may be within the range between any two of the numerical values exemplified here. Here, the width W of the convex portion is an average value of the distances between the lowest portions of the convex portions, as shown in Fig 2. In one specific example, it is the average value of the distances between the lowest points of the convex portions for 100 consecutive convex portions in an arbitrary range.

[0018]

The ratio (H/P) of the height H of the convex portion to the pitch P is preferably 0.1 to 1.0, more preferably 0.26 to 0.7, and further preferably 0.3 to 0.5. Within such a range, it is easy to mold a styrene-based resin composition, to which an antioxidant is added, with excellent extrusion stability, roll transferability, and roll releasability to produce a light guide plate having sufficient strength. Specifically, the ratio (H/P) is, for example, 0.10, 0.15, 0.20, 0.25, 0.26, 0.30, 0.31, 0.32, 0.33, 0.34, 0.35, 0.40, 0.45, 0.50, 0.55, 0.60, 0.65, 0.66, 0.67, 0.68, 0.70, and may be within the range between any two of the numerical values exemplified here.

[0019]

(Thickness)

The thickness T of the light guide plate is 1.0 to 3.0 mm, preferably 1.5 to 2.5 mm, and more preferably 1.6 to 2.4 mm. Within such a range, it is easy to mold a styrene-based resin composition, to which an antioxidant is added, with excellent extrusion stability, roll transferability, and roll releasability to produce a light guide plate having sufficient strength. Specifically, the thickness T of the light guide plate is, for example, 1.0, 1.1, 1.2, 1.3, 1.4, 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 mm, and may be within the range between any two of the numerical values exemplified here.

[0020]

[Styrene-based resin composition]

The edge light-type light guide plate of the present invention is an edge light-type light guide plate containing a styrene-based resin composition. That is, it is a molded article made of a styrene-based resin composition.

[0021]

The styrene-based resin composition comprises a styrene-based resin and a phosphorus-based antioxidant (A) and/or a phenol-based antioxidant (B).

[0022]

(Styrene-based resin)

The styrene-based resin can be obtained by polymerizing a styrene-based monomer. Examples of the styrene-based monomer include an aromatic vinyl-based monomer such as styrene, α -methylstyrene, o-methylstyrene, p-methylstyrene, m-methylstyrene, ethylstyrene, and p-t-butylstyrene. These may be used alone or a mixture of two or more may be used. The styrene-based monomer is preferably styrene. Further, it may be copolymerized with a monomer other than the styrene-based monomer as long as the characteristics of the present invention are not impaired, and examples of the monomer other than the styrene-based monomer include an acrylic monomer such as acrylic acid, methacrylic acid, butyl acrylic acid, ethyl acrylic acid, methyl acrylic acid, methyl methacrylic acid; a vinyl cyanide monomer such as acrylonitrile and methacrylonitrile; an α , β -ethylene unsaturated

carboxylic such as maleic anhydride and fumaric acid; an imide-based monomer such as phenylmaleimide and cyclohexylmaleimide. The styrene-based resin is preferably substantially composed of only the styrene-based monomer, and more preferably a homopolymer of the styrene-based monomer.

[0023]

The styrene-based resin composition is preferably composed of a styrene-based resin and various additives, and preferably comprises, for example, 90 to 99.998 parts by mass of the styrene-based resin with respect to 100 parts by mass of the styrene-based resin composition and preferably 95 to 99.98 parts by mass of the styrene-based resin. Specifically, for example, the ratio of the styrene-based resin with respect to 100 parts by mass of the styrene-based resin composition is 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 99.1, 99.2, 99.3, 99.4, 99.5, 99.6, 99.7, 99.8, 99.85, 99.88, 99.9, 99.98, 99.998 parts by mass and may be within the range between any two of the numerical values exemplified here.

[0024]

Examples of the polymerization method of the styrene-based resin include a known styrene polymerization method such as a bulk polymerization method, a solution polymerization method, a suspension polymerization method, and an emulsion polymerization method. From the viewpoint of quality and productivity, the bulk polymerization method and the solution polymerization method are preferable, and continuous polymerization is preferable. Examples of the solvent include an alkylbenzene such as benzene, toluene, ethylbenzene, and xylene, a ketone such as acetone and methyl ethyl ketone, and an aliphatic hydrocarbon such as hexane and cyclohexane.

[0025]

When polymerizing the styrene-based resin, a polymerization initiator and a chain transfer agent can be used if necessary. Examples of the polymerization initiator preferably include a radical polymerization initiator and a known radical polymerization initiator, for example, a peroxyketal such as 1,1-di (t-butylperoxy) cyclohexane, 2,2-di (t-butylperoxy) butane, 2,2-di (4,4-di-t-butylperoxycyclohexyl) propane, 1,1-di (t-amylperoxy) cyclohexane; a hydroperoxide such as cumenehydroperoxide and t-butylhydroperoxide, an alkyl peroxide such as t-butylperoxyacetate and t-amylperoxyisononanoate; a dialkyl peroxide such as t-butylcumyl peroxide, di-t-butyl peroxide, dicumyl peroxide and di-t-hexyl peroxide, a peroxyester such as t-butylperoxyacetate, t-butylperoxybenzoate, t-butylperoxyisopropylmonocarbonate; a peroxy carbonate such as t-butylperoxyisopropyl 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. These may be used alone or a mixture of two or more may be used. Examples of the chain transfer agent include an aliphatic mercaptan, an aromatic mercaptan, a pentaphenylethane, an α -methylstyrene dimer, and a terpinolene.

[0026]

4-t-butylcatechol (TBC) is often used as the polymerization inhibitor of the styrene-based monomer used for the polymerization of the styrene-based resin, and a small amount of 4-t-butylcatechol may remain in the styrene-based resin composition. Since 4-t-butylcatechol itself is a coloring component, which deteriorates the hue and lowers the transmittance, it is preferable that 4-t-butylcatechol is not contained in the styrene-based resin composition as much as possible. However, it is difficult to remove it completely. The preferred range of the

content of 4-t-butylcatechol is 0.001 to 10 $\mu\text{g/g}$, more preferably 0.01 to 8 $\mu\text{g/g}$, and particularly preferably 0.1 to 6 $\mu\text{g/g}$.

[0027]

In the case of continuous polymerization, first, in the polymerization step, a known device, for example, a complete mixing tank type stirring tank, a column reactor, or the like is used, and the polymerization reaction is controlled by adjusting the polymerization temperature or the like so as to obtain the target molecular weight, molecular weight distribution, and reaction conversion rate. The polymerization solution containing the polymer is transferred to the devolatilization step after the polymerization step, and the unreacted monomer and the polymerization solvent are removed. The devolatilization step consists of a vacuum devolatilizing tank with a heater and a devolatilizing extruder with a vent. The polymer in the molten state after the devolatilization step is transferred to the granulation step. In the granulation step, the molten resin is extruded into a strand shape from a porous die and processed into a pellet shape by a cold cut method, an air hot cut method, or an underwater hot cut method.

[0028]

The weight average molecular weight (M_w) of the styrene-based resin is preferably 200,000 to 400,000, more preferably 220,000 to 380,000, and further preferably 250,000 to 300,000. By setting it in such a range, both moldability and strength of the light guide plate can be achieved. When it is less than 200,000, the strength of the molded article becomes insufficient, and when it exceeds 400,000, the moldability is significantly lowered. Specifically, the weight average molecular weight (M_w) of the styrene-based resin is, for example, 200,000, 210,000, 220,000, 230,000, 240,000, 250,000, 260,000, 270,000, 280,000, 290,000, 300,000, 310,000, 320,000, 330,000, 340,000, 350,000, 360,000, 370,000, 380,000, 390,000, 400,000 and may be within the range between any two of the numerical values exemplified here. The weight average molecular weight of the styrene-based resin may be controlled by the reaction temperature, residence time, type and addition amount of the polymerization initiator, type and addition amount of the chain transfer agent, type and amount of the solvent used in polymerization, and the like.

[0029]

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 is preferably 1.0 to 3.0, more preferably 1.2 to 2.8, more preferably 1.5 to 2.5. Within such a range, it is easy to mold a styrene-based resin composition, to which an antioxidant is added, with excellent extrusion stability, roll transferability, and roll releasability to produce a light guide plate having sufficient strength. Specifically, 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 is, for example, 1.0, 1.1, 1.2, 1.3, 1.4, 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, and may be within the range between any two of the numerical values exemplified here. 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 can be controlled by the reaction temperature, residence time, type and addition amount of the polymerization initiator, type of the chain transfer agent, the type and amount of the solvent used in polymerization, and the like.

[0030]

(Phosphorus-based antioxidant (A)/Phenol-based antioxidant (B))

The styrene-based resin composition may contain either a phosphorus-based antioxidant (A) or a phenol-based antioxidant (B), and, by using both of them in combination, higher moldability and strength can be obtained.

[0031]

The phosphorus-based antioxidant (A) is preferably contained in an amount of 0.001 to 0.5 parts by mass, preferably 0.01 to 0.4 parts by mass, and more preferably 0.05 to 0.3 parts by mass with respect to 100 parts by mass of the styrene-based resin composition. Further, the phenol-based antioxidant (B) is preferably contained in an amount of 0.001 to 0.5 parts by mass, preferably 0.01 to 0.3 parts by mass, and more preferably 0.05 to 0.2 parts by mass with respect to 100 parts by mass of the styrene-based resin composition. Within such a range, moldability and strength are excellent. Specifically, each of the contents of the phosphorus-based antioxidant (A) and the phenol-based antioxidant (B) with respect to 100 parts by mass of the styrene-based resin composition 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, 0.10, 0.15, 0.20, 0.25, 0.30, 0.35, 0.40, 0.45, 0.50 parts by mass, and may be within the range between any two of the numerical values exemplified here.

[0032]

The phosphorus-based antioxidant (A) is, for example, at least one selected from a 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 diylbiphosphonite, bis (2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite ester.

[0033]

The phenol-based antioxidant (B) is, for example, at least one selected from a group consisting of 6- [3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propoxy] -2,4,8,10-tetra-tert-butylidibenzo [d, f] [1,3,2] dioxaphosphepine, 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], 3,9-bis [2 -[3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propionyloxy] -1,1-dimethylethyl] -2,4,8,10-tetraoxaspiro [5,5] from undecane.

A compound which has both a phosphite structure and a phenol structure in the same molecule, such as aforementioned 6- [3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propoxy] -2,4,8,10-tetra-tert-butylidibenzo [d, f] [1,3,2] dioxaphosphepine (for example, Sumilyzer GP manufactured by SUMITOMO CHEMICAL COMPANY, LIMITED), is considered to contain each of a phosphorus-based antioxidant and a phenol-based antioxidant with respect to the styrene-based resin composition. For example, when 0.1 part by mass of a phosphorus-based and phenol-based compound is contained in the styrene-based resin composition, it is considered that the styrene-based resin composition contains 0.1 part by mass of a phosphorus-based antioxidant and 0.1 part by mass of a phenol-based antioxidant with respect to 100 parts by mass of the styrene-based resin composition.

[0034]

The method for adding the phosphorus-based antioxidant (A), the phenol-based antioxidant (B), and other additives is not limited and examples of the method include a method of adding and mixing in a styrene-based resin polymerization step, a volatilization step, and a granulation step, a method of adding and mixing with an extruder or injection molding machine in molding step, and a method of diluting a resin composition, which is prepared with

a high concentration of phosphorus-based antioxidant (A) and phenol-based antioxidant (B), with an additive-free styrene-based resin and mixing them to obtain the styrene-based resin with the desired content.

[0035]

(Other additives)

The styrene-based resin composition contains various additives as long as the effects of the present invention are not impaired. Examples of the additive include a sulfur-based antioxidant, a lactone-based antioxidant, an ultraviolet absorber, a hindered amine-based stabilizer, an antistatic agent, a hydrophilic additive, and liquid paraffin (mineral oil), polyethylene wax, microcrystalline wax, and brewing agent.

[0036]

The styrene-based resin composition contains a release agent as an additive, for example, a higher fatty acid such as lauric acid, myristic acid, palmitic acid, and stearic acid; a higher fatty acid amide such as stearic acid amide, erucic acid amide, ethylene bisstearic acid amide; a higher fatty acid amide such as myristyl alcohol, cetyl alcohol, stearyl alcohol, as long as the effects of the present invention are not impaired. However, since it may deteriorate the transmittance, it is preferable not to be contained more than the required amount. The content of the release agent is preferably 500 ppm or less, more preferably 200 ppm or less, still more preferably 100 ppm or less in the styrene-based resin composition. From the viewpoint of obtaining high transmittance, it is preferable that the styrene-based resin composition contains substantially no mold release agent.

[0037]

The Vicat softening temperature of the styrene-based resin composition is preferably 95 to 104°C, more preferably 97 to 104°C. When the Vicat softening temperature is less than 95°C, the heat resistance is insufficient, and the light guide plate may be deformed depending on the usage environment.

[0038]

The degree of fogging of the styrene-based resin composition is preferably 5% or less, more preferably 1% or less in the molded article having a thickness of 4 mm.

[0039]

The average of initial transmittance at a wavelength of 380 nm to 780 nm of the styrene-based resin composition in an optical path length of 115 mm is preferably 80% or more, more preferably 84% or more.

[0040]

The average transmittance at a wavelength of 380 nm to 780 nm of the styrene-based resin composition in an optical path length of 115 mm after a long-term durability test is preferably 80% or more, more preferably 83% or more.

[0041]

The initial YI value of the styrene-based resin composition is preferably 7.0 or less, more preferably 6.0 or less.

[0042]

The difference (Δ YI) between the initial YI value and the YI value after the long-term durability test is preferably 3.0 or less, more preferably 2.0 or less, and further preferably 1.5 or less.

[0043]

The total light transmittance and the YI value were measured by the following procedure. Using pellets

of the styrene-based resin composition, injection molding was performed at a cylinder temperature of 230°C and a mold temperature of 50°C to form a plate-shaped molded article having a size of 127 × 127 mm and a thickness of 3 mm. Here, the sample for evaluating the long-term durability (sample after the long-term durability test) was stored in an oven at 80°C for 1000 hours. Next, a test piece having a size of 115 × 85 mm and a thickness of 3 mm was cut out from the plate-shaped molded article, and the end face of the plate-shaped molded article was polished by buffing to prepare the plate-shaped molded article having a mirror surface on the end face. The spectral transmittance at 350 nm to 800 nm of the polished plate-shaped molded article in an optical path length of 115 mm was measured by using an ultraviolet visible spectrophotometer V-670 manufactured by JASCO Corporation with an incident light having a size of 20 × 1.6 mm and a spreading angle of 0° and the YI value at a field of view of 2° with a C light source was calculated according to JIS K7105. The average transmittance at a wavelength of 380 nm to 780 nm is the total light transmittance.

[0044]

[Manufacturing method of light guide plate]

The edge light-type light guide plate of the present invention is obtained by molding the above-mentioned styrene-based resin composition. As a molding method, a known method such as a sheet extrusion molding, an injection molding, and a compression molding can be used. Continuous sheet extrusion molding provided with a surface shape transfer mold is preferable in terms of productivity and easy increase in size of the molded article. Examples of the sheet extrusion molding include a continuous sheet extrusion molding method comprising an extrusion step of supplying a resin in a heated and melted state to a feed block to continuously produce an extrusion sheet from a die; a pressing step of sandwiching the resin sheet between a crimping roll and a cooling roll; and a transport step of transporting the resin sheet while being in close contact with the cooling roll after the pressing step, wherein the surface of the cooling roll has a transfer mold, and by changing the shape of the transfer mold, an arbitrary concave-convex pattern can be transferred to the sheet surface.

Further, the edge light-type light guide plate of the present invention has concave-convex shapes on the front surface (light emitting surface) but has a reflection processed surface on the rear surface which diffusely reflects light. Examples of reflection processing include, for example, a silk printing, an inkjet printing, and a method of applying dot-shaped concave-convex shapes by laser irradiation. In the dot pattern printing, ink having fine particles which diffuse light can be used.

[0045]

2. Edge light-type surface light source unit

The edge light-type surface light source unit of the present invention is an edge light-type surface light source unit having an edge light-type light guide plate and a light source which supplies light to the end surface of the light guide plate. The edge light-type surface light source unit of the present invention is suitably used as a surface light source device for a liquid crystal display device.

EXAMPLES

[0046]

The present invention is described in further details below with Examples. These are merely examples and do not limit the content of the present invention.

[0047]

(Production of styrene-based resin PS-1 to PS-3)

The first reactor and the second reactor, each of which is a complete mixing type stirring tank, and the third reactor, which is a plug-flow type reactor with a static mixer, were connected in series to configure a polymerization step. The styrene-based resin was produced under the conditions shown in Table 1. The capacity of the first reactor was 39 liters, the capacity of the second reactor was 39 liters, and the capacity of the third reactor was 16 liters. A 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 at the flow rate shown in Table 1. The polymerization initiator was added to the raw material solution at the inlet of the first reactor so as to be the addition concentration (concentration by mass with respect to the raw material styrene) shown in Table 1, and uniformly mixed. The polymerization initiators listed in Table 1 are as follows.

Polymerization initiator-1: 2,2-di (4,4-t-butylperoxycyclohexyl) propane (Pertetra A manufactured by NOF CORPORATION was used)

Polymerization initiator-2: 1,1-di (t-butylperoxy) cyclohexane (Perhexa C manufactured by NOF CORPORATION was used)

The temperature of the third reactor was adjusted to have a temperature gradient along the direction of flow, and the temperature at the intermediate part and at the outlet part of the third reactor was adjusted to the temperature shown in Table 1.

Subsequently, a solution containing the polymer continuously taken out from the third reactor was introduced into a vacuum devolatilizing tank with a preheater composed of two stages in series. The temperature of the preheater was adjusted so that the resin has the temperature shown in Table 1, and the pressure was adjusted to the pressure shown in Table 1, and unreacted styrene and ethylbenzene are separated, extruded into strands from the porous die, cooled, cut and pelletized by a cold cut method.

The melt mass flow rate (MFR) was measured according to JIS K 7210 at a temperature of 200°C and a load of 49 N, and 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.

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

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

Column: PLgel 10 μ m MIXED-B manufactured by Polymer Laboratories

Mobile phase: tetrahydrofuran

Sample concentration: 0.2% by mass

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

Detector: differential refractometer

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

[0048]

[Table 1]

Table 1		condition1	condition2	condition3
resin	raw material supply flow rate	PS-1	PS-2	PS-3
		12.0	11.2	12.6
polymerization initiator-1	styrene	83.5	84.0	81.5
	ethylbenzene	16.5	16.0	18.5
	% by mass	-	400	150
	% by mass	-	-	100
polymerization initiator-2	ppm *1	-	-	100
	ppm *1	-	-	100
reaction temperature	first reactor	132	116	120
	second reactor	132	120	135
	third reactor	135	140	145
	(intermediate part)			
	third reactor (outlet part)	140	150	155
first devolatilizing tank	resin temperature	160	160	160
	pressure	65	65	65
second devolatilizing tank	resin temperature	230	235	230
	pressure	0.8	0.8	0.8
	Mn	15.0	12.0	7.5
	Mw	27.0	37.0	28.0
	Mz	43.5	72.0	59.2
molecular weight	Mw/Mn	1.80	3.08	3.73
	Mz/Mw	1.61	1.95	2.11
	Mz/Mw	2.3	1.1	2.7
melt mass flow rate	q/10min	102	103	101
	Vicat softening temperature	102	103	101

*1 concentration by mass with respect to total monomer

[0049]

[Examples 1 to 19, Comparative Examples 1 to 7]

<Preparation of resin composition>

Styrene-based resins PS-1, PS-2, PS-3, and phosphorus-based antioxidant (A) and/or phenol-based antioxidant (B) are melt-kneaded using a single-screw extruder with a screw diameter of 40 mm, at a cylinder temperature of 230°C and a screw rotation speed of 100 rpm at the contents shown in Tables 2 and 3 to obtain pellets.

[0050]

The phosphorus-based antioxidants (A) and phenol-based antioxidants (B) in Tables 2 and 3 are as follows, respectively.

[0051]

(Phosphorus-based antioxidant (A))

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

168: tris (2,4-di-tert-butylphenyl) phosphite (Irgafos 168 manufactured by 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 (ADEKA STAB PEP-36 manufactured by ADEKA Corporation)

P-EPQ: tetrakis (2,4-di-tert-butylphenyl) [1,1 biphenyl] -4,4 diylbiphosphonite (Hostanox P-EPQ manufactured by Clariant Co. Ltd.)

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

[0052]

(Phenol-based antioxidant (B))

GP: 6- [3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propoxy] -2,4,8,10-tetra-tert-butyl-dibenzo [d, f] [1,3 2] dioxaphosphine (Sumilyzer GP manufactured by SUMITOMO CHEMICAL COMPANY)

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

245: ethylene bis (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.)

AO80: 3,9-bis [2- [3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propionyloxy] -1,1-dimethylethyl] -2,4,8,10-tetra Oxaspiro [5.5] undecane (Adeka Stub AO-80 manufactured by ADEKA Corporation)

[0053]

<Evaluation of optical properties of resin composition>

Using the obtained pellets, injection molding was performed at a cylinder temperature of 230°C and a mold temperature of 50°C to form a plate-shaped molded article having a size of 127 × 127 mm and a thickness of 3 mm. In order to evaluate the long-term durability, the obtained molded article was stored in an oven at 80°C for 1000 hours. In order to evaluate the optical properties of the initial molded article before storage (initial sample)

and the molded article after storage (sample after long-term durability test), a test piece with a size of 115×85 mm and a thickness of 3 mm was cut out from the plate-shaped molded article. The end face was polished by buffing to prepare a plate-shaped molded article having a mirror surface on the end face. The spectral transmittance at 350 nm to 800 nm of the polished plate-shaped molded article in an optical path length of 115 mm was measured by using an ultraviolet visible spectrophotometer V-670 manufactured by JASCO Corporation with an incident light having a size of 20×1.6 mm and a spreading angle of 0° and the YI value at a field of view of 2° with a C light source was calculated according to JIS K7105. The total light transmittance shown in Tables 2 and 3 represents the average transmittance at a wavelength of 380 nm to 780 nm.

[0054]

<Production of light guide plate>

As shown in Fig. 3, the obtained pellets are supplied to a single-screw extruder 5 having a screw diameter of 120 mm and $L/D = 32$, the cylinder temperature is set to 150 to 230°C , and melt kneading is performed. Then, via a gear pump 7, the sheet was extruded from a T-die 9 having a width of 1500 mm at a resin temperature of 260° . Subsequently, the extruded sheet is sandwiched between the crimping roll 11 (mirror surface cooling roll) and the first cooling roll 13 (mirror surface cooling roll), transported in a state of being wound around the first cooling roll 13, and then further sandwiched between the first cooling roll 13 and the second cooling roll 15 (transfer mold mounted roll) to transfer the concave-convex shapes to one side of the resin sheet. Then the resin sheet peeled off from the second cooling roll 15 was picked up by the pick-up roll 17 at a pick-up speed of 5.2 m/min. The crimping roll 11, the first cooling roll 13, and the second cooling roll 15 are chrome-plated, and the temperatures of the crimping roll 11, the first cooling roll 13, and the second cooling roll 15 were set to $80^\circ\text{C}/85^\circ\text{C}/90^\circ\text{C}$, respectively. Further, by changing the shape of the transfer mold mounted on the second cooling roll 15, a resin sheet having the surface convex shape shown in Tables 2 and 3 was obtained.

[0055]

In Tables 2 and 3, "shape", "height P", "pitch P", and "H/P" are values defined above, respectively, and "lenti" means "lenticular".

[0056]

<Evaluation of moldability and strength of light guide plate>

The extrusion stability (die drool), roll transferability, roll releasability, and light guide plate strength in production of the light guide plate manufacturing in Tables 2 and 3 were evaluated as follows.

[0057]

(Extrusion stability (die drool))

The resin temperature of the die was adjusted to 300°C , and the state of drool near the die was evaluated based on the following criteria.

- A: No die drool is confirmed even 30 minutes after the start of sheet extrusion.
- B: Die drool is confirmed 10 to 30 minutes after the start of sheet extrusion.
- C: Die drool is confirmed within 10 minutes after the start of sheet extrusion.

The "die drool" is a deteriorated brown or black resin generated around the outlet nozzle of the die, and usually increases with the extrusion amount, and when it exceeds a certain amount, it is detached from the nozzle

and adheres to the sheet surface.

[0058]

(Roll transferability)

The roll transfer rate T was determined by the following formula, and the roll transferability was evaluated based on the following criteria.

Roll transfer rate T (%) = Height of convex portion of resin sheet H/Depth of concave portion of transfer type H' × 100

A: 95% or more

B: 85 to 95%

C: 85% or less

[0059]

(Roll releasability)

The resin temperature of the die was adjusted to 270°C or 290°C, and after continuous extrusion at each temperature for 30 minutes, the appearance of the sheet surface was observed. The roll releasability was evaluated based on the following criteria.

A: No change was observed in appearance at 290°C

B: Rough skin or whitening on the sheet surface was observed at 290°C, and no change was observed in appearance at 270°C.

C: Rough skin or whitening on the sheet surface was observed at 270°C.

[0060]

(Strength)

A 200 mm × 200 mm test piece was cut out from the resin sheet obtained above, and a ball weighing 16.6 g was used to measure a 50% fracture height according to JIS K-7211. The strength of the light guide plate of the 50% fracture height was measured and evaluated based on the following criteria.

A: 50 cm or more

B: 30 to 50 cm

C: 30 cm or less

Table 2-2			Example									
shape	thickness T			11	12	13	14	15	16	17	18	19
				2.5	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
shape	surface convex portion	shape	mm	lenti	prism	prism	lenti	lenti	lenti	lenti	lenti	lenti
		height H	-	196	147	276	98	90	24	98	98	92
		pitch P	μm	300	300	300	300	300	70	400	300	300
		H/P	-	0.65	0.49	0.92	0.33	0.30	0.34	0.25	0.33	0.31
		type	-	PS-1	PS-1	PS-1	PS-1	PS-2	PS-1	PS-1	PS-1	PS-3
resin composition	styrene-based resin	addition amount										
		amount	part	99.80	99.80	99.80	99.98	99.80	99.80	99.80	99.90	99.80
	phosphorus-based antioxidant phenol-based antioxidant (B)	type	-	HP-10	HP-10	HP-10	168	HP-10	HP-10	HP-10	168	HP-10
		addition amount	part	0.1	0.1	0.1	0.01	0.1	0.1	0.1	0.1	0.1
		type	-	GP	GP	GP	1076	GP	GP	GP	-	GP
optical properties of resin composition	initial hue	addition amount	part	0.1	0.1	0.1	0.01	0.1	0.1	0.1	-	0.1
		total light transmittance	%	86	86	86	85	86	86	86	86	86
	hue after long-term durability test (80°C×1,000h)	YI value	-	5.7	5.5	5.4	5.7	5.7	5.7	5.7	5.3	5.3
		total light transmittance	%	85	85	85	81	81	85	85	80	80
		YI value	-	7	6.8	6.7	9.5	9.5	7	7	10.1	10.1
moldability of light guide plate	extrusion stability (die drool)	ΔYI	-	1.3	1.3	1.3	3.8	3.8	1.3	1.3	4.8	4.8
		roll transferability	-	A	A	A	B	A	A	A	B	A
	roll transferability	roll transferability	-	A	A	B	A	B	A	A	A	B
		roll releasability	-	A	A	A	A	B	A	A	A	B
	strength of light guide plate		-	A	A	A	A	A	B	B	B	B

[0062]

[Table 3]

Table 3			Comparative Example						
			1	2	3	4	5	6	7
shape	thickness T	mm	3.5	3.5	3.5	4.0	0.8	2.0	2.0
	shape		lenti	lenti	lenti	lenti	prism	lenti	lenti
	height H	μm	81	82	82	82	83	96	90
	pitch P	μm	300	300	300	300	200	300	300
	H / P	-	0.27	0.27	0.27	0.27	0.42	0.32	0.30
resin composition	type	-	PS-1	PS-1	PS-1	PS-1	PS-1	PS-1	PS-3
	addition amount	part	99.80	99.80	99.80	99.80	99.80	100	100
	type	-	HP-10	168	168	168	168	-	-
	addition amount	part	0.1	0.1	0.1	0.1	0.1	-	-
	type	-	GP	GP	1076	1076	1076	-	-
optical properties of resin composition	addition amount	part	0.1	0.1	0.1	0.1	0.1	-	-
	total light transmittance	%	85	85	84	84	84	84	83
	YI value	-	5.8	5.9	6.3	6.0	6.0	6.0	6.3
	total light transmittance	%	84	84	83	82	83	79	77
	YI value	-	7	7.3	7.8	7.5	7.5	12.1	12.1
moldability of light guide plate	ΔYI	-	1.2	1.4	1.5	1.5	1.5	6.1	5.8
	extrusion stability (die drool)	-	A	A	A	A	A	C	C
	roll transferability	-	C	C	C	C	C	A	C
	roll releasability	-	C	C	C	C	B	A	B
	strength of light guide plate	-	B	B	B	B	B	B	C

Reference List

[0063]

1: Light guide plate, 3A: Convex part (lenticular-shaped), 3B: Convex part (prism-shaped), 5: Single shaft extruder, 7: Gear pump, 9: T-die, 11: Crimping roll, 13: First cooling roll, 15: Second cooling roll, 17: Pick-up roll

We claim that:

1. An edge light-type light guide plate containing a styrene-based resin composition, wherein:
a surface of the edge light-type light guide plate has a plurality of lenticular-shaped and/or prism-shaped convex portions;
a thickness T of the edge light-type light guide plate is 1.0 to 3.0 mm;
the styrene-based resin composition comprises a styrene-based resin and a phosphorus-based antioxidant (A) and/or a phenol-based antioxidant (B); and
at least one of the following conditions (1) and (2) is satisfied:
(1) a height H of the convex portions is 10 to 500 μm ;
(2) a pitch P between the convex portions is 30 to 800 μm .
2. The edge light-type light guide plate of Claim 1, wherein the height H of the convex portions is 10 to 500 μm , and the pitch P between the convex portions is 30 to 800 μm .
3. The edge light-type light guide plate of Claim 1 or 2, comprising 0.001 to 0.5 parts by mass of the phosphorus-based antioxidant (A) and 0.001 to 0.5 parts by mass of the phenol-based antioxidant (B) with respect to 100 parts by mass of the styrene-based resin composition.
4. The edge light-type light guide plate of any one of Claims 1 to 3, wherein the phosphorus-based antioxidant (A) is at least one selected from a 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 diylbiphosphonite, bis (2,4-di-tert-butyl-6-methylphenyl) ethyl phosphite ester.
5. The edge light-type light guide plate of any one of Claims 1 to 4, wherein the phenol-based antioxidant (B) is at least one selected from a group consisting of 6- [3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propoxy] -2,4,8,10-tetra-tert-butylidibenzo [d, f] [1,3,2] dioxaphosphine, 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], 3,9-bis [2- [3- (3-tert-butyl-4-hydroxy-5-methylphenyl) propionyloxy] -1,1-dimethylethyl] -2,4,8,10-tetraoxaspiro [5,5] undecane.
6. The edge light-type light guide plate of any one of Claims 1 to 5, wherein a weight average molecular weight (Mw) of the styrene-based resin is 200,000 to 400,000, and a ratio (Mw/Mn) of the weight average molecular weight (Mw) to a number average molecular weight (Mn) of the styrene-based resin is 1.0 to 3.0.
7. The edge light-type light guide plate of any one of Claims 1 to 6, wherein the styrene-based resin composition has an initial average transmittance of 80% or more at a wavelength of 380 to 780 nm in an optical path length of 115 mm.
8. An edge light-type surface light source unit comprising the edge light-type light guide plate of any one of Claims 1 to 7 and a light source for supplying light to an end surface of the edge light-type light guide plate.