

Description

Title of Invention: OPTICAL LAMINATE AND IMAGE DISPLAY APPARATUS INCLUDING POLARIZING PLATE WITH RETARDATION LAYERS OF THE OPTICAL LAMINATE

Technical Field

[0001] The present invention relates to an optical laminate and an image display apparatus including a polarizing plate with retardation layers of the optical laminate.

Background Art

[0002] In recent years, image display apparatus typified by a liquid crystal display apparatus and an electroluminescence (EL) display apparatus (e.g., an organic EL display apparatus or an inorganic EL display apparatus) have been rapidly gaining more widespread use. In the image display apparatus, a polarizing plate and a retardation plate have been typically used. In practical use, a polarizing plate with a retardation layer, in which the polarizing plate, the retardation plate, and a pressure-sensitive adhesive layer are integrated, has been widely used (for example, Patent Literature 1). In this connection, recently, along with an increasing demand for the thinning of the image display apparatus, there has also been an increasing demand for the thinning of the polarizing plate with a retardation layer. In addition, in recent years, there has

been a growing demand for a curved image display apparatus and/or a bendable or foldable image display apparatus. However, when a polarizing plate with a retardation layer that is thin and excellent in bendability, the polarizing plate with a retardation layer being applicable to such image display apparatus, is cut into a predetermined size or a predetermined shape, adhesive deficiency (phenomenon in which an end portion of the pressure-sensitive adhesive layer of the polarizing plate with a retardation layer is lost), adhesive contamination (phenomenon in which contamination occurs in the end portion of the pressure-sensitive adhesive layer), and a cutting failure may occur.

Citation List

Patent Literature

[0003] [PTL 1] JP 3325560 B2

Summary of Invention

Technical Problem

[0004] The present invention has been made to solve the above-described conventional problems, and a primary object of the present invention is to provide an optical laminate, which includes a polarizing plate with retardation layers that is thin and has excellent bendability, and is suppressed from causing adhesive deficiency, adhesive contamination, and a cutting

failure at the time of its cutting.

Solution to Problem

[0005] An optical laminate according to an embodiment of the present invention includes: a polarizing plate with retardation layers including a polarizing plate including a polarizer and a protective layer arranged on at least a viewer side of the polarizer, a first retardation layer bonded to a side of the polarizing plate opposite to a viewer side thereof via a first adhesive layer, a second retardation layer bonded to the first retardation layer via a second adhesive layer, and a pressure-sensitive adhesive layer arranged on a side of the second retardation layer opposite to the first retardation layer; a surface protective film temporarily bonded to a viewer side of the polarizing plate with retardation layers in a peelable manner; and a separator temporarily bonded to the pressure-sensitive adhesive layer of the polarizing plate with retardation layers in a peelable manner, wherein when a thickness of the pressure-sensitive adhesive layer is represented by T_{PSA} , a thickness of the polarizing plate with retardation layers is represented by T_{PWR} , and a thickness of the optical laminate is represented by T_{OL} , the following relationships are satisfied:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{PSA}/T_{OL} \leq 0.29.$$

An optical laminate according to an embodiment of the present invention includes: a polarizing plate with retardation layers including a polarizing plate including a polarizer and a protective layer arranged on at least a viewer side of the polarizer, a first retardation layer bonded to a side of the polarizing plate opposite to a viewer side thereof via a first adhesive layer, a second retardation layer bonded to the first retardation layer via a second adhesive layer, and a pressure-sensitive adhesive layer arranged on a side of the second retardation layer opposite to the first retardation layer; a surface protective film temporarily bonded to a viewer side of the polarizing plate with retardation layers in a peelable manner; and a separator temporarily bonded to the pressure-sensitive adhesive layer of the polarizing plate with retardation layers in a peelable manner, wherein when a thickness of the pressure-sensitive adhesive layer is represented by T_{PSA} , a thickness of the polarizing plate with retardation layers is represented by T_{PWR} , and a thickness of the separator is represented by T_{SP} , the following relationships are satisfied:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{SP}/T_{PSA} \geq 0.8.$$

In one embodiment of the present invention, the T_{PSA} , the T_{PWR} , the T_{OL} , and the T_{SP} satisfy the following relationships:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{\text{PSA}}/T_{\text{OL}} \leq 0.29$$

$$T_{\text{SP}}/T_{\text{PSA}} \geq 0.8.$$

In one embodiment of the present invention, the thickness T_{PSA} of the pressure-sensitive adhesive layer is 20 μm or more.

In one embodiment of the present invention, a thickness of the polarizer is 8 μm or less.

In one embodiment of the present invention, the pressure-sensitive adhesive layer has a storage modulus of elasticity at 25°C of from 1.0×10^4 Pa to 1.0×10^6 Pa.

In one embodiment of the present invention, the thickness T_{PWR} of the polarizing plate with retardation layers is 100 μm or less.

In one embodiment of the present invention, the polarizing plate includes the protective layer only on the viewer side of the polarizer.

In one embodiment of the present invention, the first retardation layer and the second retardation layer are each an alignment fixed layer of a liquid crystal compound.

In one embodiment of the present invention, the first retardation layer has an $\text{Re}(550)$ of from 200 nm to 300 nm, and a slow axis thereof and an absorption axis of the polarizer form an angle of from 10° to 20° , and the second retardation layer has an $\text{Re}(550)$ of from 100 nm to 190 nm, and a slow axis thereof and the absorption axis of the polarizer form an angle of from 70° to 80° .

According to another aspect of the present invention, an image display apparatus is provided. The image display apparatus includes the polarizing plate with retardation layers of the optical laminate as described above.

In one embodiment of the present invention, the image display apparatus is an organic electroluminescence display apparatus.

Advantageous Effects of Invention

[0006] According to the embodiments of the present invention, in the optical laminate including the polarizing plate with retardation layers that is thin and has excellent bendability, the surface protective film, and the separator, the mutual relationships among the thickness of the optical laminate, the thickness of the polarizing plate with retardation layers, the thickness of the pressure-sensitive adhesive layer, and the

thickness of the separator are optimized. Accordingly, the optical laminate that is suppressed from causing adhesive deficiency, adhesive contamination, and a cutting failure at the time of its cutting can be achieved.

Brief Description of Drawings

[0007] FIG. 1 is a schematic sectional view of an optical laminate according to one embodiment of the present invention.

Description of Embodiments

[0008] Embodiments of the present invention are described below. However, the present invention is not limited to these embodiments.

[0009] (Definitions of Terms and Symbols)

The definitions of terms and symbols used herein are as described below.

(1) Refractive Indices (n_x , n_y , and n_z)

" n_x " represents a refractive index in a direction in which an in-plane refractive index is maximum (that is, slow axis direction), " n_y " represents a refractive index in a direction perpendicular to the slow axis in the plane (that is, fast axis direction), and " n_z " represents a refractive index in a thickness direction.

(2) In-plane Retardation (Re)

"Re(λ)" refers to an in-plane retardation measured at 23°C with light having a wavelength of λ nm. For example, "Re(550)" refers to an in-plane retardation measured at 23°C with light having a wavelength of 550 nm. The Re(λ) is determined from the equation "Re(λ)=(n_x-n_y) $\times$ d" when the thickness of a layer (film) is represented by d (nm).

(3) Thickness Direction Retardation (Rth)

"Rth(λ)" refers to a thickness direction retardation measured at 23°C with light having a wavelength of λ nm. For example, "Rth(550)" refers to a thickness direction retardation measured at 23°C with light having a wavelength of 550 nm. The Rth(λ) is determined from the equation "Rth(λ)=(n_x-n_z) $\times$ d" when the thickness of a layer (film) is represented by d (nm).

(4) Nz Coefficient

An Nz coefficient is determined from the equation "Nz=Rth/Re".

(5) Angle

When reference is made to an angle herein, the angle encompasses both angles in a clockwise direction and a counterclockwise direction with respect to a reference direction.

[0010] A. Overall Configuration of Polarizing Plate with Retardation Layers

FIG. 1 is a schematic sectional view of an optical laminate according to one embodiment of the present invention. An optical laminate **100** of the illustrated example includes: a polarizing plate **70** with retardation layers; a surface protective film **50** temporarily bonded to the viewer side of the polarizing plate **70** with retardation layers in a peelable manner; and a separator **60** temporarily bonded to the side of the polarizing plate **70** with retardation layers opposite to the viewer side in a peelable manner. The polarizing plate **70** with retardation layers typically includes a polarizing plate **10**, a first retardation layer **21**, and a second retardation layer **22** in the stated order from the viewer side. The polarizing plate **10** includes a polarizer **11** and a protective layer **12** arranged on the viewer side of the polarizer **11**. Another protective layer (not shown) may be arranged on the side of the polarizer **11** opposite to the viewer side in accordance with purposes. The first retardation layer **21** is bonded to the side of the polarizing plate **10** opposite to its viewer side via a first adhesive layer **31**. The second retardation layer **22** is bonded to the side of the first retardation layer **21** opposite to its viewer side via a second adhesive layer **32**. Practically, a pressure-sensitive adhesive layer **40** is arranged on the side of the second retardation layer

22 opposite to the first retardation layer **21** (i.e., as an outermost layer opposite to the viewer side), and hence the polarizing plate with retardation layers can be bonded to an image display cell. The separator **60** is temporarily bonded to the surface of the pressure-sensitive adhesive layer **40** in a peelable manner. The temporary bonding of the separator protects the pressure-sensitive adhesive layer, and enables the formation of the optical laminate into a roll. The surface protective film **50** typically includes a substrate and a pressure-sensitive adhesive layer (none of the substrate and the layer is shown), and is temporarily bonded to the polarizing plate with retardation layers (substantially, the viewer-side protective layer **12**) via the pressure-sensitive adhesive layer in a peelable manner. At the time of actual use of the optical laminate (substantially, the polarizing plate with retardation layers), the separator **60** is peeled and removed, and the polarizing plate **70** with retardation layers is bonded to an image display apparatus (substantially, the image display cell) via the pressure-sensitive adhesive layer **40**. The surface protective film **50** is also peeled and removed at the time of the actual use of the optical laminate (substantially, the polarizing plate with retardation layers).

[0011] The first retardation layer **21** and the second retardation layer **22** are each typically an alignment fixed layer

of a liquid crystal compound. When the liquid crystal compound is used, a difference between the n_x and the n_y of a retardation layer to be obtained can be made much larger than that of a non-liquid crystal material, and hence the thickness of a retardation layer for obtaining a desired in-plane retardation can be markedly reduced. As a result, significant thinning of the polarizing plate with retardation layers can be achieved. The term "alignment fixed layer" as used herein refers to the following layer: the liquid crystal compound is aligned in a predetermined direction in the layer, and its alignment state is fixed. The term "alignment fixed layer" is a concept encompassing an alignment cured layer obtained by curing a liquid crystal monomer as described later. In each of the first retardation layer **21** and the second retardation layer **22**, the molecules of a rod-shaped liquid crystal compound are typically aligned under the state of being lined up in the slow axis direction of the first retardation layer or the second retardation layer (homogeneous alignment). Typically, one of the first retardation layer **21** and the second retardation layer **22** can function as a $\lambda/2$ plate, and the other can function as a $\lambda/4$ plate. For example, when the first retardation layer **21** can function as a $\lambda/2$ plate, and the second retardation layer **22** can function as a $\lambda/4$ plate, the $R_e(550)$ of the first retardation layer **21** is preferably from 200 nm to 300 nm, and an angle formed by the slow axis thereof and the absorption axis of the polarizer

10 is preferably from 10° to 20°; and the Re(550) of the second retardation layer **22** is preferably from 100 nm to 190 nm, and an angle formed by the slow axis thereof and the absorption axis of the polarizer **10** is preferably from 70° to 80°.

[0012] In one embodiment of the present invention, when the thickness of the optical laminate **100** is represented by T_{OL} , the thickness of the polarizing plate **70** with retardation layers is represented by T_{PWR} , the thickness of the pressure-sensitive adhesive layer **40** is represented by T_{PSA} , and the thickness of the separator **60** is represented by T_{SP} , the optical laminate satisfies the following relationships:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{PSA}/T_{OL} \leq 0.29.$$

The fact that the ratio T_{PSA}/T_{PWR} is 0.4 or more typically means that the thickness of the pressure-sensitive adhesive layer is large in the polarizing plate with retardation layers having a small entire thickness. For example, when an attempt is made to apply a polarizing plate with a retardation layer to a bendable or foldable image display apparatus, a conventional polarizing plate with a retardation layer has been unable to secure such bendability as to be capable of withstanding use in such image display apparatus. In contrast, a polarizing plate with retardation layers having predetermined bendability can be achieved by reducing its entire thickness and making its

pressure-sensitive adhesive layer relatively thick. The inventors of the present invention have found a new problem in that when such polarizing plate with retardation layers is cut into a predetermined size or a predetermined shape, adhesive deficiency, adhesive contamination, and/or a cutting failure may occur. The inventors of the present invention have assumed that the ratio of the pressure-sensitive adhesive layer having a modulus of elasticity lower than that of the constituent film of the polarizing plate with retardation layers is large, and hence the deformation of the pressure-sensitive adhesive layer at the time of the cutting may be related to the problem. The inventors have made extensive investigations on the basis of the assumption, and as a result, have found that the problem can be solved by controlling the thicknesses of the surface protective film and the separator temporarily bonded to the polarizing plate with retardation layers to set the ratio T_{PSA}/T_{OL} to 0.29 or less. Thus, the inventors have completed the present invention. That is, when a force to be applied to the pressure-sensitive adhesive layer at the time of the cutting is reduced (consequently, the deformation of the pressure-sensitive adhesive layer at the time of the cutting is reduced) by increasing the modulus of elasticity of the entirety of the optical laminate (i.e., the apparent modulus of elasticity thereof) through the control of the thicknesses of the surface protective film and the separator, the adhesive deficiency, the adhesive contamination, and the

cutting failure at the time of the cutting of the polarizing plate with retardation layers can be suppressed while a preferred configuration of the polarizing plate with retardation layers to be actually used is kept unchanged. Further, as described later in Examples, with regard to, for example, the adhesive contamination, it has been recognized that when the ratio T_{PSA}/T_{OL} is about 0.3, the adhesive contamination occurs at a ratio of 100%, but when the ratio T_{PSA}/T_{OL} is about 0.28, the occurrence ratio of the adhesive contamination is drastically reduced to 20%. That is, it is found that a critical value is present at a ratio T_{PSA}/T_{OL} of around 0.29. As described above, the optical laminate according to the embodiment of the present invention solves the problem newly found for the polarizing plate with retardation layers, and its effect is an unexpected and excellent effect having critical significance.

[0013] In another embodiment of the present invention, the optical laminate satisfies the following relationships:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{SP}/T_{PSA} \geq 0.8.$$

The inventors of the present invention have found on the basis of the same assumption and investigations as those described above that the above-mentioned problem (the adhesive deficiency, the adhesive contamination, and/or the cutting failure at the time of the cutting) newly found for the polarizing plate with

retardation layers that is thin and has excellent bendability, the polarizing plate with retardation layers being applied to, for example, a bendable or foldable image display apparatus, can also be solved by setting the ratio T_{SP}/T_{PSA} to 0.8 or more. More specifically, an increase in thickness of the separator adjacent to the pressure-sensitive adhesive layer can largely contribute to the prevention of the deformation of the pressure-sensitive adhesive at the time of the cutting, and as a result, can suppress the adhesive deficiency, the adhesive contamination, and the cutting failure at the time of the cutting.

[0014] In the optical laminate, the T_{PSA} , the T_{PWR} , the T_{OL} , and the T_{SP} preferably satisfy the following relationships:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{PSA}/T_{OL} \leq 0.29$$

$$T_{SP}/T_{PSA} \geq 0.8.$$

The ratio T_{PSA}/T_{PWR} is preferably from 0.42 to 0.75, more preferably from 0.45 to 0.65. The ratio T_{PSA}/T_{OL} is preferably 0.25 or less, more preferably 0.20 or less, still more preferably 0.18 or less. The ratio T_{PSA}/T_{OL} may be, for example, 0.10 or more. The ratio T_{SP}/T_{PSA} is preferably 0.9 or more, more preferably 1.2 or more, still more preferably 1.4 or more. The ratio T_{SP}/T_{PSA} may be, for example, 3.0 or less.

[0015] The total thickness of the polarizing plate with

retardation layers is preferably 100 μm or less, more preferably 85 μm or less, still more preferably 70 μm or less, particularly preferably 60 μm or less. The lower limit of the total thickness may be, for example, 42 μm . The polarizing plate with retardation layers having such total thickness may have extremely excellent flexibility and extremely excellent bendability. As a result, the polarizing plate with retardation layers may be particularly suitably applied to a curved image display apparatus and/or a bendable or foldable image display apparatus.

[0016] The polarizing plate with retardation layers may further include any other optical functional layer. The kinds, characteristics, number, combination, arrangement positions, and the like of the optical functional layers that may be arranged in the polarizing plate with retardation layers may be appropriately set in accordance with purposes. For example, the polarizing plate with retardation layers may further include a conductive layer or an isotropic substrate with a conductive layer (none of the layers is shown). The conductive layer or the isotropic substrate with a conductive layer is typically arranged outside the second retardation layer **22** (side opposite to the polarizing plate **10**). The conductive layer or the isotropic substrate with a conductive layer is typically any appropriate layer to be arranged as required, and may be omitted.

When the conductive layer or the isotropic substrate with a conductive layer is arranged, the polarizing plate with retardation layers may be applied to a so-called inner touch panel-type input display apparatus obtained by incorporating a touch sensor between an image display cell (e.g., an organic EL cell) and a polarizing plate. In addition, the polarizing plate with retardation layers may further include, for example, any other retardation layer. The optical characteristics (e.g., refractive index characteristic, in-plane retardation, Nz coefficient, and photoelastic coefficient), thickness, arrangement position, and the like of the other retardation layer may be appropriately set in accordance with purposes.

[0017] The above-mentioned embodiments may be combined as appropriate, modifications obvious in the art may be made to the constituent elements in the embodiments, and the configurations in the embodiments may each be replaced with an optically equivalent configuration.

[0018] The optical laminate may be of a sheet shape, or may be of an elongate shape. The term "elongate" as used herein means a long and narrow shape whose length is sufficiently long as compared to its width, and includes, for example, a long and narrow shape whose length is 10 or more times, preferably 20 or more times as long as its width. The polarizing plate with

retardation layers of an elongate shape can be wound in a roll shape.

[0019] The constituent elements of the polarizing plate with retardation layers are described in more detail below.

[0020] B. Polarizing Plate

B-1. Polarizer

Any appropriate polarizer may be adopted as the polarizer **11**. For example, a resin film forming the polarizer may be a single-layer resin film, or may be a laminate of two or more layers.

[0021] Specific examples of the polarizer including a single-layer resin film include: a polarizer obtained by subjecting a hydrophilic polymer film, such as a polyvinyl alcohol (PVA)-based film, a partially formalized PVA-based film, or an ethylene-vinyl acetate copolymer-based partially saponified film, to dyeing treatment with a dichroic substance, such as iodine or a dichroic dye, and stretching treatment; and a polyene-based alignment film, such as a dehydration-treated product of PVA or a dehydrochlorination-treated product of polyvinyl chloride. A polarizer obtained by dyeing the PVA-based film with iodine and uniaxially stretching the resultant is preferably used because the polarizer is excellent in optical

characteristics.

[0022] The dyeing with iodine is performed by, for example, immersing the PVA-based film in an aqueous solution of iodine. The stretching ratio of the uniaxial stretching is preferably from 3 times to 7 times. The stretching may be performed after the dyeing treatment, or may be performed while the dyeing is performed. In addition, the dyeing may be performed after the stretching has been performed. The PVA-based film is subjected to swelling treatment, cross-linking treatment, washing treatment, drying treatment, or the like as required. For example, when the PVA-based film is immersed in water to be washed with water before the dyeing, contamination or an antiblocking agent on the surface of the PVA-based film can be washed off. In addition, the PVA-based film is swollen and hence dyeing unevenness or the like can be prevented.

[0023] The polarizer obtained by using the laminate is specifically, for example, a polarizer obtained by using a laminate of a resin substrate and a PVA-based resin layer (PVA-based resin film) laminated on the resin substrate, or a laminate of a resin substrate and a PVA-based resin layer formed on the resin substrate through application. The polarizer obtained by using the laminate of the resin substrate and the PVA-based resin layer formed on the resin substrate through application may be

produced by, for example, a method involving: applying a PVA-based resin solution onto the resin substrate; drying the solution to form the PVA-based resin layer on the resin substrate, to thereby provide the laminate of the resin substrate and the PVA-based resin layer; and stretching and dyeing the laminate to turn the PVA-based resin layer into the polarizer. In this embodiment, the stretching typically includes the stretching of the laminate under a state in which the laminate is immersed in an aqueous solution of boric acid. The stretching may further include the aerial stretching of the laminate at high temperature (e.g., 95°C or more) before the stretching in the aqueous solution of boric acid as required. The resultant laminate of the resin substrate and the polarizer may be used as it is (i.e., the resin substrate may be used as a protective layer for the polarizer). Alternatively, a product obtained as described below may be used: the resin substrate is peeled from the laminate of the resin substrate and the polarizer, and any appropriate protective layer in accordance with purposes is laminated on the peeling surface. Details about such method of producing a polarizer are described in, for example, JP 2012-73580 A or JP 6470455 B. The entire description of the patent publications is incorporated herein by reference.

[0024] The thickness of the polarizer is preferably 15 μm or less, more preferably from 1 μm to 12 μm , still more

preferably from 3 μm to 12 μm , particularly preferably from 3 μm to 8 μm . When the thickness of the polarizer falls within such ranges, the above-mentioned desired ratios $T_{\text{PSA}}/T_{\text{PWR}}$ and $T_{\text{PSA}}/T_{\text{OL}}$ can be easily achieved. Further, the curling of the polarizer at the time of its heating can be satisfactorily suppressed, and satisfactory appearance durability thereof at the time of the heating is obtained.

[0025] The polarizer preferably shows absorption dichroism at any wavelength in the wavelength range of from 380 nm to 780 nm. The single layer transmittance of the polarizer is preferably from 41.5% to 46.0%, more preferably from 43.0% to 46.0%, still more preferably from 44.5% to 46.0%. The polarization degree of the polarizer is preferably 97.0% or more, more preferably 99.0% or more, still more preferably 99.9% or more.

[0026] B-2. Protective Layer

The protective layer **12** and another protective layer (if present) are each formed of any appropriate film that may be used as a protective layer for a polarizer. A material serving as a main component of the film is specifically, for example: a cellulose-based resin, such as triacetylcellulose (TAC); a transparent resin, such as a polyester-based, polyvinyl alcohol-based, polycarbonate-based, polyamide-based, polyimide-based,

polyether sulfone-based, polysulfone-based, polystyrene-based, polynorbornene-based, polyolefin-based, (meth)acrylic, or acetate-based transparent resin; or a thermosetting resin or a UV-curable resin, such as a (meth)acrylic, urethane-based, (meth)acrylic urethane-based, epoxy-based, or silicone-based thermosetting resin or UV-curable resin. A further example thereof is a glassy polymer, such as a siloxane-based polymer. In addition, a polymer film described in JP 2001-343529 A (WO 01/37007 A1) may be used. For example, a resin composition containing a thermoplastic resin having a substituted or unsubstituted imide group on a side chain thereof, and a thermoplastic resin having a substituted or unsubstituted phenyl group and a nitrile group on side chains thereof may be used as the material for the film, and the composition is, for example, a resin composition containing an alternating copolymer formed of isobutene and N-methylmaleimide, and an acrylonitrile-styrene copolymer. The polymer film may be, for example, an extrudate of the resin composition.

[0027] The polarizing plate with retardation layers is typically arranged on the viewer side of an image display apparatus as described later, and the protective layer **12** is arranged on its viewer side. Accordingly, the protective layer **12** may be subjected to surface treatment, such as hard coat treatment, antireflection treatment, anti-sticking treatment, or

antiglare treatment, as required. Further/alternatively, the protective layer **12** may be subjected to treatment for improving viewability when the display screen of the apparatus is viewed through polarized sunglasses (typically the impartment of a circular (elliptical) polarization function or the impartment of an ultra-high retardation) as required. When such treatment is performed, even in the case where the display screen is viewed through a polarizing lens, such as polarized sunglasses, excellent viewability can be achieved. Accordingly, the polarizing plate with retardation layers is suitably applicable even to an image display apparatus that may be used outdoors.

[0028] The thickness of the protective layer **12** is preferably from 5 μm to 80 μm , more preferably from 10 μm to 40 μm , still more preferably from 10 μm to 30 μm . When the protective layer **12** is subjected to surface treatment, its thickness is a thickness including the thickness of the surface-treated layer.

[0029] In one embodiment, it is preferred that the other protective layer (if present) be optically isotropic. The phrase "be optically isotropic" as used herein means that the layer has an in-plane retardation $\text{Re}(550)$ of from 0 nm to 10 nm, and a thickness direction retardation $\text{Rth}(550)$ of from -10 nm to +10 nm. The thickness of the other protective layer is preferably

from 5 μm to 80 μm , more preferably from 10 μm to 40 μm , still more preferably from 10 μm to 30 μm . From the viewpoint of thinning, the other protective layer may be preferably omitted.

[0030] C. First Retardation Layer and Second Retardation Layer

As described above, the first retardation layer **21** and the second retardation layer **22** (hereinafter sometimes collectively referred to as "retardation layers") are each an alignment fixed layer of a liquid crystal compound (hereinafter referred to as "liquid crystal alignment fixed layer"). An example of the liquid crystal compound is a liquid crystal compound whose liquid crystal phase is a nematic phase (nematic liquid crystal). As such liquid crystal compound, for example, a liquid crystal polymer or a liquid crystal monomer may be used. The expression mechanism of the liquid crystallinity of the liquid crystal compound may be lyotropic or thermotropic. The liquid crystal polymer and the liquid crystal monomer may be used alone or in combination thereof.

[0031] When the liquid crystal compound is the liquid crystal monomer, the liquid crystal monomer is preferably a polymerizable monomer or a cross-linkable monomer. This is because the alignment state of the liquid crystal monomer can be fixed by polymerizing or cross-linking (that is, curing) the

liquid crystal monomer. After the alignment of the liquid crystal monomer, for example, when molecules of the liquid crystal monomer are polymerized or cross-linked with each other, the alignment state can be fixed as a result. In this case, a polymer is formed through the polymerization and a three-dimensional network structure is formed through the cross-linking, and the polymer and the structure are non-liquid crystalline. Accordingly, the formed retardation layer does not undergo, for example, a transition caused by a temperature change to a liquid crystal phase, a glass phase, or a crystal phase, which is peculiar to a liquid crystalline compound. As a result, the retardation layer becomes a retardation layer that is extremely excellent in stability without being affected by a temperature change.

[0032] The temperature range in which the liquid crystal monomer shows liquid crystallinity varies depending on its kind. Specifically, the temperature range is preferably from 40°C to 120°C, more preferably from 50°C to 100°C, most preferably from 60°C to 90°C.

[0033] Any appropriate liquid crystal monomer may be adopted as the liquid crystal monomer. For example, a polymerizable mesogenic compound and the like described in JP 2002-533742 A (WO 00/37585 A1), EP 358208 B1 (US 5211877 A), EP

66137 B1 (US 4388453 A), WO 93/22397 A1, EP 0261712 A1, DE 19504224 A1, DE 4408171 A1, GB 2280445 B, and the like may be used. Specific examples of such polymerizable mesogenic compound include a product available under the product name LC242 from BASF SE, a product available under the product name E7 from Merck KGaA, and a product available under the product name LC-Sillicon-CC3767 from Wacker Chemie AG. The liquid crystal monomer is preferably, for example, a nematic liquid crystal monomer.

[0034] The liquid crystal alignment fixed layer may be formed by: subjecting the surface of a predetermined substrate to alignment treatment; applying an application liquid containing a liquid crystal compound onto the surface; aligning the liquid crystal compound in a direction corresponding to the alignment treatment; and fixing the alignment state. In one embodiment, the substrate is any appropriate resin film, and the liquid crystal alignment fixed layer (first retardation layer **21**) formed on the substrate may be transferred onto the surface of the polarizing plate **10** via the first adhesive layer **31**. Similarly, the liquid crystal alignment fixed layer (second retardation layer **22**) formed on the substrate may be transferred onto the surface of the first retardation layer **21** via the first adhesive layer **32**.

[0035] Any appropriate alignment treatment may be adopted as the alignment treatment. Specific examples thereof include mechanical alignment treatment, physical alignment treatment, and chemical alignment treatment. Specific examples of the mechanical alignment treatment include rubbing treatment and stretching treatment. Specific examples of the physical alignment treatment include magnetic field alignment treatment and electric field alignment treatment. Specific examples of the chemical alignment treatment include an oblique deposition method and photoalignment treatment. Any appropriate conditions may be adopted as treatment conditions for the various alignment treatments in accordance with purposes.

[0036] The alignment of the liquid crystal compound is performed through treatment at a temperature at which the liquid crystal compound shows a liquid crystal phase depending on the kind of the liquid crystal compound. When the treatment at such temperature is performed, the liquid crystal compound adopts a liquid crystal state, and the liquid crystal compound is aligned depending on the alignment treatment direction of the surface of the substrate.

[0037] In one embodiment, the fixation of the alignment state is performed by cooling the liquid crystal compound aligned as described above. When the liquid crystal compound is the

polymerizable monomer or the cross-linkable monomer, the fixation of the alignment state is performed by subjecting the liquid crystal compound aligned as described above to polymerization treatment or cross-linking treatment.

[0038] Specific examples of the liquid crystal compound and details of the method of forming the alignment fixed layer are described in JP 2006-163343 A, the description of which is incorporated herein by reference.

[0039] The refractive index characteristic of the retardation layer typically shows a relationship of $n_x > n_y = n_z$. The equation " $n_y = n_z$ " encompasses not only a case in which the n_y and the n_z are completely equal to each other, but also a case in which the n_y and the n_z are substantially equal to each other. Accordingly, the n_y may be larger than the n_z , or the n_y may be smaller than the n_z to the extent that the effect of the present invention is not impaired.

[0040] As described above, one of the first retardation layer **21** and the second retardation layer **22** can function as a $\lambda/2$ plate, and the other can function as a $\lambda/4$ plate. Herein, a case in which the first retardation layer **21** can function as a $\lambda/2$ plate, and the second retardation layer **22** can function as a $\lambda/4$ plate is described, but the opposite case is also permitted.

The thickness of the first retardation layer **21** may be adjusted so that the desired in-plane retardation of the $\lambda/2$ plate may be obtained, and the thickness may be, for example, from 2.0 μm to 4.0 μm . The thickness of the second retardation layer **22** may be adjusted so that the desired in-plane retardation of the $\lambda/4$ plate may be obtained, and the thickness may be, for example, from 1.0 μm to 2.5 μm . The in-plane retardation $\text{Re}(550)$ of the first retardation layer is preferably from 200 nm to 300 nm as described above, and is more preferably from 230 nm to 290 nm, still more preferably from 250 nm to 280 nm. The in-plane retardation $\text{Re}(550)$ of the second retardation layer is preferably from 100 nm to 190 nm as described above, and is more preferably from 110 nm to 170 nm, still more preferably from 130 nm to 160 nm. An angle formed by the slow axis of the first retardation layer **21** and the absorption axis of the polarizer **10** is preferably from 10° to 20° as described above, more preferably from 12° to 18° , still more preferably about 15° . An angle formed by the slow axis of the second retardation layer **22** and the absorption axis of the polarizer **10** is preferably from 70° to 80° as described above, more preferably from 72° to 78° , still more preferably about 75° . With such configuration, a characteristic close to an ideal reverse wavelength dispersion characteristic can be obtained, and as a result, an extremely excellent antireflection characteristic can be achieved.

[0041] The Nz coefficient of the retardation layer is preferably from 0.9 to 1.5, more preferably from 0.9 to 1.3. When such relationship is satisfied, in the case where the polarizing plate with retardation layers to be obtained is used in an image display apparatus, an extremely excellent reflection hue can be achieved.

[0042] The retardation layer may show such a reverse wavelength dispersion characteristic that its retardation value increases with an increase in wavelength of measurement light, may show such a positive wavelength dispersion characteristic that the retardation value reduces with an increase in wavelength of the measurement light, or may show such a flat wavelength dispersion characteristic that the retardation value remains substantially unchanged even when the wavelength of the measurement light changes.

[0043] D. Adhesive Layers

The first adhesive layer **31** and the second adhesive layer **32** are collectively described as adhesive layers. The first adhesive layer and the second adhesive layer may have the same configuration, or may have configurations different from each other. Any appropriate adhesive may be adopted as each of the adhesives for forming the adhesive layers. The adhesive is typically, for example, an active energy ray-curable adhesive.

Examples of the active energy ray-curable adhesive include a UV-curable adhesive and an electron beam-curable adhesive. In addition, from the viewpoint of a curing mechanism, examples of the active energy ray-curable adhesive include adhesives of a radical curing type, a cation curing type, an anion curing type, and a radical curing-cation curing hybrid type. A UV-curable adhesive of a radical curing type may be typically used. This is because the adhesive is excellent in general-purpose property and its characteristics (configuration) can be easily adjusted.

[0044] The adhesive typically contains a curable component and a photopolymerization initiator. Typical examples of the curable component include monomers and/or oligomers each having a functional group, such as a (meth)acrylate group or a (meth)acrylamide group. Specific examples of the curable component include tripropylene glycol diacrylate, 1,9-nonanediol diacrylate, tricyclodecane dimethanol diacrylate, phenoxydiethylene glycol acrylate, cyclic trimethylolpropane formal acrylate, dioxane glycol diacrylate, EO-modified diglycerin tetraacrylate, γ -butyrolactone acrylate, acryloylmorpholine, an unsaturated fatty acid hydroxyalkyl ester-modified ϵ -caprolactone, N-methylpyrrolidone, hydroxyethylacrylamide, N-methylolacrylamide, N-methoxymethylacrylamide, and N-ethoxymethylacrylamide. Those curable components may be used alone or in combination thereof.

[0045] The adhesive preferably contains a curable component having a heterocycle. Examples of the curable component having a heterocycle include acryloylmorpholine, γ -butyrolactone acrylate, an unsaturated fatty acid hydroxyalkyl ester-modified ϵ -caprolactone, and N-methylpyrrolidone. More preferred curable components are an unsaturated fatty acid hydroxyalkyl ester-modified ϵ -caprolactone and acryloylmorpholine, and a particularly preferred curable component is acryloylmorpholine. The curable component having a heterocycle may be incorporated into the adhesive at a ratio of preferably 50 parts by weight or more, more preferably 60 parts by weight or more, still more preferably from 70 parts by weight to 95 parts by weight with respect to 100 parts by weight of the curable components (when an oligomer component to be described later is present, the total of the curable components and the oligomer component). Acryloylmorpholine may be incorporated into the adhesive at a ratio of preferably from 5 parts by weight to 60 parts by weight, more preferably from 10 parts by weight to 50 parts by weight with respect to 100 parts by weight of the curable components (when the oligomer component is present, the total of the curable components and the oligomer component).

[0046] The adhesive may further contain an oligomer component in addition to the above-mentioned curable component.

The use of the oligomer component can reduce the viscosity of the adhesive before its curing to improve its operability. A typical example of the oligomer component is a (meth)acrylic oligomer. Examples of a (meth)acrylic monomer for forming the (meth)acrylic oligomer include (meth)acrylic acid (C1 to C20) alkyl esters, cycloalkyl (meth)acrylates (e.g., cyclohexyl (meth)acrylate and cyclopentyl (meth)acrylate), aralkyl (meth)acrylates (e.g., benzyl (meth)acrylate), polycyclic (meth)acrylates (e.g., 2-isobornyl (meth)acrylate, 2-norbornylmethyl (meth)acrylate, 5-norbornen-2-yl-methyl (meth)acrylate, and 3-methyl-2-norbornylmethyl (meth)acrylate), hydroxyl group-containing (meth)acrylic acid esters (e.g., hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, and 2,3-dihydroxypropylmethyl-butyl (meth)acrylate), alkoxy group or phenoxy group-containing (meth)acrylic acid esters (e.g., 2-methoxyethyl (meth)acrylate, 2-ethoxyethyl (meth)acrylate, 2-methoxymethoxyethyl (meth)acrylate, 3-methoxybutyl (meth)acrylate, ethylcarbitol (meth)acrylate, and phenoxyethyl (meth)acrylate), epoxy group-containing (meth)acrylic acid esters (e.g., glycidyl (meth)acrylate), halogen-containing (meth)acrylic acid esters (e.g., 2,2,2-trifluoroethyl (meth)acrylate, 2,2,2-trifluoroethylethyl (meth)acrylate, tetrafluoropropyl (meth)acrylate, hexafluoropropyl (meth)acrylate, octafluoropentyl (meth)acrylate, and heptafluorodecyl (meth)acrylate), and

alkylaminoalkyl (meth)acrylates (e.g., dimethylaminoethyl (meth)acrylate). Specific examples of the (meth)acrylic acid (C1 to C20) alkyl esters include methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, 2-methyl-2-nitropropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, s-butyl (meth)acrylate, t-butyl (meth)acrylate, n-pentyl (meth)acrylate, t-pentyl (meth)acrylate, 3-pentyl (meth)acrylate, 2,2-dimethylbutyl (meth)acrylate, n-hexyl (meth)acrylate, cetyl (meth)acrylate, n-octyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, 4-methyl-2-propylpentyl (meth)acrylate, and n-octadecyl (meth)acrylate. Those (meth)acrylates may be used alone or in combination thereof.

[0047] A detailed description of the photopolymerization initiator is omitted because a photopolymerization initiator that is well known in the art may be used in a blending amount that is well known in the art.

[0048] The thickness of each of the adhesive layers (after the curing of the adhesive) is preferably from 0.1 μm to 3.0 μm . When the adhesive layers each have such thickness, the above-mentioned desired ratios $T_{\text{PSA}}/T_{\text{PWR}}$ and $T_{\text{PSA}}/T_{\text{OL}}$ can be easily achieved.

[0049] Details of the adhesive are described in, for example,

JP 2018-017996 A, the description of which is incorporated herein by reference.

[0050] E. Pressure-sensitive Adhesive Layer

The storage modulus of elasticity of the pressure-sensitive adhesive layer at 25°C is preferably from 1.0×10^4 Pa to 1.0×10^6 Pa, more preferably from 1.0×10^4 Pa to 1.0×10^5 Pa. When the storage modulus of elasticity of the pressure-sensitive adhesive layer falls within such ranges, adhesive deficiency, adhesive contamination, and a cutting failure at the time of the cutting of the optical laminate (substantially, the polarizing plate with retardation layers) can be suppressed by a synergistic effect with an effect exhibited by the optimization of the above-mentioned ratios T_{PSA}/T_{PWR} , T_{PSA}/T_{OL} , and T_{SP}/T_{PSA} . The storage modulus of elasticity can be obtained by dynamic viscoelasticity measurement.

[0051] The creep amount ΔCr of the pressure-sensitive adhesive layer at 70°C is, for example, 65 μm or less, and may be 50 μm or less, 45 μm or less, 40 μm or less, 35 μm or less, 30 μm or less, 25 μm or less, 20 μm or less, and 15 μm or less. The lower limit of the creep amount ΔCr is, for example, 0.5 μm . When the creep amount falls within such ranges, as in the case of the storage modulus of elasticity, the adhesive deficiency, the adhesive contamination, and the cutting failure at the time

of the cutting of the optical laminate (substantially, the polarizing plate with retardation layers) can be suppressed. The creep value may be measured by, for example, the following procedure: a load of 500 gf is applied vertically downward to the pressure-sensitive adhesive layer bonded to a stainless steel-made test plate in a joining surface measuring 20 mm long by 20 mm wide under a state in which the test plate is fixed; the creep amounts (shift amounts) of the pressure-sensitive adhesive layer with respect to the test plate at respective time points after the lapse of 100 seconds from the start of the application of the load and after the lapse of 3,600 seconds therefrom are measured, and are represented by Cr_{100} and Cr_{3600} , respectively; and the creep amount ΔCr can be determined from the Cr_{100} and the Cr_{3600} thus measured by using the equation " $\Delta Cr = Cr_{3600} - Cr_{100}$."

[0052] Any appropriate configuration may be adopted as the pressure-sensitive adhesive for forming the pressure-sensitive adhesive layer. Specific examples of the pressure-sensitive adhesive for forming the pressure-sensitive adhesive layer include an acrylic pressure-sensitive adhesive, a rubber-based pressure-sensitive adhesive, a silicone-based pressure-sensitive adhesive, a polyester-based pressure-sensitive adhesive, a urethane-based pressure-sensitive adhesive, an epoxy-based pressure-sensitive adhesive, and a polyether-based

pressure-sensitive adhesive. A pressure-sensitive adhesive having desired characteristics in accordance with purposes can be prepared by adjusting, for example, the kinds, number, combination, and blending ratios of monomers for forming the base resin of the pressure-sensitive adhesive, and the blending amount of a cross-linking agent, a reaction temperature, and a reaction time. The base resins of the pressure-sensitive adhesive may be used alone or in combination thereof. From the viewpoints of, for example, transparency, processability, and durability, an acrylic pressure-sensitive adhesive (acrylic pressure-sensitive adhesive composition) is preferred. The acrylic pressure-sensitive adhesive composition typically contains a (meth)acrylic polymer as a main component. The (meth)acrylic polymer may be incorporated into the pressure-sensitive adhesive composition at a ratio of, for example, 50 wt% or more, preferably 70 wt% or more, more preferably 90 wt% or more with respect to the solid content of the pressure-sensitive adhesive composition. The (meth)acrylic polymer contains, as a main component, an alkyl (meth)acrylate serving as a monomer unit. The term "(meth)acrylate" refers to an acrylate and/or a methacrylate. The alkyl (meth)acrylate may be incorporated at a ratio of preferably 80 wt% or more, more preferably 90 wt% or more into monomer components for forming the (meth)acrylic polymer. An example of the alkyl group of the alkyl (meth)acrylate is a linear or branched alkyl group having

1 to 18 carbon atoms. The average number of carbon atoms of the alkyl group is preferably from 3 to 9, more preferably from 3 to 6. The alkyl (meth)acrylate is preferably butyl acrylate. Examples of the monomer (copolymerizable monomer) for forming the (meth)acrylic polymer include, in addition to the alkyl (meth)acrylate, a carboxyl group-containing monomer, a hydroxyl group-containing monomer, an amide group-containing monomer, an aromatic ring-containing (meth)acrylate, and a heterocycle-containing vinyl-based monomer. Typical examples of the copolymerizable monomer include acrylic acid, 4-hydroxybutyl acrylate, phenoxyethyl acrylate, and N-vinyl-2-pyrrolidone. The acrylic pressure-sensitive adhesive composition may preferably contain a silane coupling agent and/or a cross-linking agent. An example of the silane coupling agent is an epoxy group-containing silane coupling agent. Examples of the cross-linking agent include an isocyanate-based cross-linking agent and a peroxide-based cross-linking agent. Further, the acrylic pressure-sensitive adhesive composition may contain an antioxidant and/or a conductive agent. Details of the pressure-sensitive adhesive layer or the acrylic pressure-sensitive adhesive composition are described in, for example, JP 2006-183022 A, JP 2015-199942 A, JP 2018-053114 A, JP 2016-190996 A, and WO 2018/008712 A1, the descriptions of which are incorporated herein by reference.

[0053] The thickness of the pressure-sensitive adhesive layer is preferably 20 μm or more, more preferably from 20 μm to 70 μm , still more preferably from 20 μm to 65 μm , particularly preferably from 25 μm to 55 μm . When the thickness of the pressure-sensitive adhesive layer falls within such ranges, the above-mentioned desired ratios $T_{\text{PSA}}/T_{\text{PWR}}$, $T_{\text{PSA}}/T_{\text{OL}}$, and $T_{\text{SP}}/T_{\text{PSA}}$ can be easily achieved.

[0054] F. Surface Protective Film

As described above, the surface protective film **50** typically includes the substrate and the pressure-sensitive adhesive layer. The pressure-sensitive adhesive layer of the surface protective film may be referred to as "PF pressure-sensitive adhesive layer" in order to distinguish the layer from the pressure-sensitive adhesive layer **40**. The substrate may include any appropriate material. Specific examples of the material for forming the substrate include: polyester-based polymers, such as polyethylene terephthalate (PET), polyethylene naphthalate (PEN), and polybutylene terephthalate (PBT); cellulose-based polymers, such as diacetylcellulose and triacetylcellulose; polycarbonate-based polymers; (meth)acrylic polymers, such as polymethyl methacrylate; and cycloolefin-based polymers, such as polynorbornene. Those materials may be used alone or in combination thereof.

[0055] The tensile modulus of elasticity of the substrate is preferably from 1.0×10^8 Pa to 1.0×10^{10} Pa, more preferably from 1.0×10^9 Pa to 1.0×10^{10} Pa. When the tensile modulus of elasticity of the substrate falls within such ranges, an effect exhibited by setting the ratios T_{PSA}/T_{PWR} , T_{PSA}/T_{OL} , and T_{SP}/T_{PSA} within the above-mentioned predetermined ranges becomes significant. The tensile modulus of elasticity is measured in conformity with JIS K 7161.

[0056] Any appropriate configuration may be adopted as the PF pressure-sensitive adhesive layer. Specific examples thereof include an acrylic pressure-sensitive adhesive, a rubber-based pressure-sensitive adhesive, a silicone-based pressure-sensitive adhesive, a polyester-based pressure-sensitive adhesive, a urethane-based pressure-sensitive adhesive, an epoxy-based pressure-sensitive adhesive, and a polyether-based pressure-sensitive adhesive. A pressure-sensitive adhesive having desired characteristics in accordance with purposes can be prepared by adjusting, for example, the kinds, number, combination, and blending ratios of monomers for forming the base resin of the pressure-sensitive adhesive, and the blending amount of a cross-linking agent, a reaction temperature, and a reaction time. The base resins of the pressure-sensitive adhesive may be used alone or in combination thereof. The base resin is preferably an acrylic resin (i.e., the PF pressure-

sensitive adhesive layer preferably includes the acrylic pressure-sensitive adhesive). The storage modulus of elasticity of the PF pressure-sensitive adhesive layer at 25°C may be, for example, from 1.0×10^5 Pa to 1.0×10^7 Pa.

[0057] The thickness of the surface protective film is preferably from 30 μm to 80 μm , more preferably from 40 μm to 60 μm . When the thickness of the surface protective film falls within such ranges, the above-mentioned desired ratio $T_{\text{PSA}}/T_{\text{OL}}$ can be easily achieved. The thickness of the surface protective film refers to the total thickness of the substrate and the PF pressure-sensitive adhesive layer.

[0058] G. Separator

Any appropriate separator may be adopted as the separator 60. A specific example thereof is a plastic film, a non-woven fabric, or paper whose surface has been coated with a peeling agent. Specific examples of the peeling agent include a silicone-based peeling agent, a fluorine-based peeling agent, and a long-chain alkyl acrylate-based peeling agent. Specific examples of the plastic film include a polyethylene terephthalate (PET) film, a polyethylene film, and a polypropylene film.

[0059] The thickness of the separator is preferably from 20

μm to 80 μm , more preferably from 35 μm to 55 μm . When the thickness of the separator falls within such ranges, the above-mentioned desired ratio $T_{\text{PSA}}/T_{\text{OL}}$ can be easily achieved.

[0060] H. Image Display Apparatus

The optical laminate (substantially, the polarizing plate with retardation layers) described in the section A to the section G may be applied to an image display apparatus. Accordingly, an image display apparatus including the optical laminate (substantially, the polarizing plate with retardation layers) is also included in an embodiment of the present invention. The image display apparatus typically includes an image display cell and the polarizing plate with retardation layers bonded to the image display cell via the pressure-sensitive adhesive layer. Typical examples of the image display apparatus include a liquid crystal display apparatus and an electroluminescence (EL) display apparatus (e.g., an organic EL display apparatus or an inorganic EL display apparatus). In one embodiment, the image display apparatus is an organic EL display apparatus. In one embodiment, the image display apparatus has a curved shape (substantially, a curved display screen) and/or is bendable or foldable. In such image display apparatus, the effect of the optical laminate (substantially, the polarizing plate with retardation layers) according to the embodiment of the present invention becomes significant.

Examples

[0061] Now, the present invention is specifically described by way of Examples. However, the present invention is not limited by these Examples. Measurement methods for characteristics are as described below. The terms "part(s)" and "%" in Examples and Comparative Example mean "part(s) by weight" and "wt%", respectively unless otherwise stated.

(1) Thickness

A thickness of 10 μm or less was measured with an interference thickness meter (manufactured by Otsuka Electronics Co., Ltd., product name: "MCPD-3000"). A thickness of more than 10 μm was measured with a digital micrometer (manufactured by Anritsu Corporation, product name: "KC-351C").

(2) Adhesive Contamination

Optical laminates obtained in Examples, Comparative Example, and Reference Examples were each press-cut into a size measuring 100 mm by 50 mm with a cutting machine. The presence or absence of contamination by a pressure-sensitive adhesive in an end portion of the cut-out optical laminate was observed visually and with an optical microscope. Similar observation was performed on the 50 cut-out optical laminates, and the ratio of the laminates in which the adhesive contamination occurred

was calculated.

[0062] [Example 1]

1. Production of Polarizing Plate

An amorphous isophthalic acid-copolymerized polyethylene terephthalate film (thickness: 100 μm) having an elongate shape and a T_g of about 75°C was used as a thermoplastic resin substrate, and one surface of the resin substrate was subjected to corona treatment.

A product obtained by adding 13 parts by weight of potassium iodide to 100 parts by weight of a PVA-based resin, which had been obtained by mixing polyvinyl alcohol (polymerization degree: 4,200, saponification degree: 99.2 mol%) and acetoacetyl-modified PVA (manufactured by the Nippon Synthetic Chemical Industry Co., Ltd., product name: "Gohsefimer") at 9:1, was dissolved in water to prepare a PVA aqueous solution (application liquid).

The PVA aqueous solution was applied to the corona-treated surface of the resin substrate, and was dried at 60°C to form a PVA-based resin layer having a thickness of 13 μm . Thus, a laminate was produced.

The resultant laminate was uniaxially stretched in its

longitudinal direction (lengthwise direction) at a ratio of 2.4 times in an oven at 130°C (in-air auxiliary stretching treatment).

Next, the laminate was immersed in an insolubilizing bath having a liquid temperature of 40°C (aqueous solution of boric acid obtained by blending 100 parts by weight of water with 4 parts by weight of boric acid) for 30 seconds (insolubilizing treatment).

Next, the laminate was immersed in a dyeing bath having a liquid temperature of 30°C (aqueous solution of iodine obtained by blending 100 parts by weight of water with iodine and potassium iodide at a weight ratio of 1:7) for 60 seconds while the concentration of the aqueous solution was adjusted so that the single layer transmittance (T_s) of a polarizer to be finally obtained became a desired value (dyeing treatment).

Next, the laminate was immersed in a cross-linking bath having a liquid temperature of 40°C (aqueous solution of boric acid obtained by blending 100 parts by weight of water with 3 parts by weight of potassium iodide and 5 parts by weight of boric acid) for 30 seconds (cross-linking treatment).

After that, while the laminate was immersed in an aqueous solution of boric acid having a liquid temperature of 70°C (boric

acid concentration: 4 wt%, potassium iodide concentration: 5 wt%), the laminate was uniaxially stretched in the longitudinal direction (lengthwise direction) between rolls having different peripheral speeds so that the total stretching ratio became 5.5 times (underwater stretching treatment).

After that, the laminate was immersed in a washing bath having a liquid temperature of 20°C (aqueous solution obtained by blending 100 parts by weight of water with 4 parts by weight of potassium iodide) (washing treatment).

After that, the laminate was brought into contact with a SUS-made heating roll whose surface temperature was kept at about 75°C while being heated in an oven kept at about 90°C (drying shrinkage treatment).

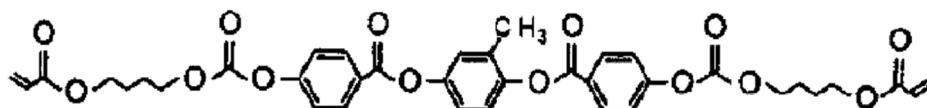
Thus, a polarizer having a thickness of about 5 μm was formed on the resin substrate to provide a polarizing plate having the configuration "resin substrate/polarizer."

Further, an acrylic film ("RV-20UB" manufactured by Toyo Kohan Co., Ltd., thickness: 20 μm) was bonded as a protective substrate (protective layer) to the surface of the resultant polarizer (surface opposite to the resin substrate) via a UV-curable adhesive. Specifically, the curable adhesive was

applied so that its total thickness became about 1.0 μm , followed by the bonding with a rolling mill. After that, UV light was applied from the acrylic film side to cure the adhesive. Next, the resin substrate was peeled. Thus, a polarizing plate having the configuration "acrylic film (protective layer)/polarizer" was obtained.

[0063] 2. Production of First Retardation Layer and Second Retardation Layer

10 Grams of a polymerizable liquid crystal compound showing a nematic liquid crystal phase (manufactured by BASF SE: product name: "Paliocolor LC242," represented by the below-indicated formula) and 3 g of a photopolymerization initiator for the polymerizable liquid crystal compound (manufactured by BASF SE: product name: "IRGACURE 907") were dissolved in 40 g of toluene to prepare a liquid crystal composition (application liquid).



The surface of a polyethylene terephthalate (PET) film (thickness: 38 μm) was subjected to alignment treatment by rubbing with a rubbing cloth. The direction of the alignment treatment was set so as to be a direction of 15° with respect to

the direction of the absorption axis of the polarizer as seen from a viewer side in bonding to the polarizing plate. The liquid crystal application liquid was applied to the alignment-treated surface with a bar coater, and was dried by heating at 90°C for 2 minutes to align the liquid crystal compound. Light was applied in an irradiance of 1 mJ/cm² to the thus-formed liquid crystal layer with a metal halide lamp to cure the liquid crystal layer. Thus, a liquid crystal alignment fixed layer A was formed on the PET film. The liquid crystal alignment fixed layer A had a thickness of 2 μm and an in-plane retardation Re(550) of 270 nm. Further, the liquid crystal alignment fixed layer A showed a refractive index distribution of $n_x > n_y = n_z$. The liquid crystal alignment fixed layer A was used as a first retardation layer.

A liquid crystal alignment fixed layer B was formed on the PET film in the same manner as described above except that: the application thickness was changed; and the direction of the alignment treatment was set so as to be a direction of 75° with respect to the direction of the absorption axis of the polarizer as seen from a viewer side. The liquid crystal alignment fixed layer B had a thickness of 1 μm and an in-plane retardation Re(550) of 140 nm. Further, the liquid crystal alignment fixed layer B showed a refractive index distribution of $n_x > n_y = n_z$. The liquid crystal alignment fixed layer B was used as a second

retardation layer.

[0064] 3. Production of Polarizing Plate with Retardation Layers

The liquid crystal alignment fixed layer A (first retardation layer) and the liquid crystal alignment fixed layer B (second retardation layer) obtained in the section 2. were transferred in the stated order onto the surface of the polarizer of the polarizing plate obtained in the section 1. At this time, the transfers (bondings) were performed so that an angle formed by the absorption axis of the polarizer and the slow axis of the alignment fixed layer A became 15° , and an angle formed by the absorption axis of the polarizer and the slow axis of the alignment fixed layer B became 75° . Each transfer (bonding) was performed via a UV-curable adhesive (thickness: $1.0\ \mu\text{m}$). Finally, an acrylic pressure-sensitive adhesive layer (thickness T_{PSA} : $25\ \mu\text{m}$) was arranged on the surface of the alignment fixed layer B (second retardation layer). Thus, a polarizing plate with retardation layers having the configuration "protective layer/adhesive/polarizer/first adhesive layer/first retardation layer/second adhesive layer/second retardation layer/pressure-sensitive adhesive layer" was obtained. The thickness T_{PWR} of the resultant polarizing plate with retardation layers was $56\ \mu\text{m}$.

[0065] 4. Production of Optical Laminate

A surface protective film (thickness: 48 μm) was bonded to the surface of the protective layer of the polarizing plate with retardation layers obtained in the section 3. Further, a separator (thickness T_{SP} : 38 μm) was bonded to the surface of the pressure-sensitive adhesive layer to provide an optical laminate. The thickness T_{OL} of the resultant optical laminate was 142 μm . The resultant optical laminate was subjected to the evaluation (2). The result is shown in Table 1.

[0066] [Example 2]

A polarizing plate with retardation layers was produced in the same manner as in Example 1 except that the thickness T_{PSA} of the pressure-sensitive adhesive layer was set to 50 μm . An optical laminate was produced in the same manner as in Example 1 except that: the polarizing plate with retardation layers was used; and the T_{SP} of the separator was set to 50 μm . The resultant optical laminate was subjected to the same evaluation as that of Example 1. The result is shown in Table 1.

[0067] [Example 3]

A polarizing plate with retardation layers was produced in the same manner as in Example 1. An optical laminate was produced in the same manner as in Example 1 except that the T_{SP} of the separator was set to 50 μm . The resultant optical

laminate was subjected to the same evaluation as that of Example 1. The result is shown in Table 1.

[0068] [Comparative Example 1]

A polarizing plate with retardation layers was produced in the same manner as in Example 1 except that the thickness T_{PSA} of the pressure-sensitive adhesive layer was set to 50 μm . An optical laminate was produced in the same manner as in Example 1 except that the polarizing plate with retardation layers was used. The resultant optical laminate was subjected to the same evaluation as that of Example 1. The result is shown in Table 1.

[0069] [Reference Example 1]

A polarizing plate with retardation layers was produced in the same manner as in Example 1 except that: an HC-COP film having a thickness of 27 μm was used as a protective layer; and the thickness T_{PSA} of the pressure-sensitive adhesive layer was set to 15 μm . The HC-COP film was obtained by forming a hard coat (HC) layer having a thickness of 2 μm on a cycloolefin-based resin (COP) film having a thickness of 25 μm , and was bonded so that the HC layer was on a viewer side. An optical laminate was produced in the same manner as in Example 1 except that the polarizing plate with retardation layers was used. The resultant optical laminate was subjected to the same evaluation

as that of Example 1. The result is shown in Table 1.

[0070] [Reference Example 2]

A polarizing plate with retardation layers was produced in the same manner as in Example 2 except that: an HC-COP film having a thickness of 27 μm was used as a protective layer; and the thickness T_{PSA} of the pressure-sensitive adhesive layer was set to 15 μm . The HC-COP film was obtained by forming a hard coat (HC) layer having a thickness of 2 μm on a cycloolefin-based resin (COP) film having a thickness of 25 μm , and was bonded so that the HC layer was on a viewer side. An optical laminate was produced in the same manner as in Example 1 except that the polarizing plate with retardation layers was used. The resultant optical laminate was subjected to the same evaluation as that of Example 1. The result is shown in Table 1.

[0071] [Reference Example 3]

An elongate roll of a PVA-based resin film having a thickness of 30 μm was uniaxially stretched in its elongate direction with a roll stretching machine so that the total stretching ratio became 6.0 times. Simultaneously with the stretching, the roll was subjected to swelling treatment, dyeing treatment, cross-linking treatment, and washing treatment. Finally, the roll was subjected to drying treatment to produce a polarizer having a thickness of 12 μm . A COP-HC film was

bonded as a viewer-side protective layer to one surface of the resultant polarizer via a PVA-based adhesive (thickness: 1 μm). The COP-HC film was obtained by forming a hard coat (HC) layer having a thickness of 7 μm on a cycloolefin-based resin (COP) film having a thickness of 25 μm , and was bonded so that the HC layer was on a viewer side. Further, a triacetylcellulose (TAC) film (thickness: 25 μm) was bonded to the other surface of the polarizer via a PVA-based adhesive to provide a polarizing plate having the configuration "protective layer (COP-HC film)/polarizer/protective layer (TAC film)." Hereinafter, a polarizing plate with retardation layers having the configuration "viewer-side protective layer/adhesive/polarizer/adhesive/protective layer/first adhesive layer/first retardation layer/second adhesive layer/second retardation layer/pressure-sensitive adhesive layer" was obtained in the same manner as in Example 1 except that the thickness T_{PSA} of the pressure-sensitive adhesive layer was set to 30 μm . The thickness T_{PWR} of the resultant polarizing plate with retardation layers was 105 μm . An optical laminate was produced in the same manner as in Example 1 except that the polarizing plate with retardation layers was used. The resultant optical laminate was subjected to the same evaluation as that of Example 1. The result is shown in Table 1.

[0072] [Reference Example 4]

A polarizing plate with retardation layers was produced in the same manner as in Reference Example 3. An optical laminate was produced in the same manner as in Example 1 except that: the polarizing plate with retardation layers was used; and the T_{SP} of the separator was set to 50 μm . The resultant optical laminate was subjected to the same evaluation as that of Example 1. The result is shown in Table 1.

[0073]

Table 1

	T_{OL} (μm)	T_{PWR} (μm)	T_{PSA} (μm)	T_{SP} (μm)	T_{PSA}/T_{PWR}	T_{PSA}/T_{OL}	T_{SP}/T_{PSA}	Adhesive contamination (%)
Example 1	142	56	25	38	0.446	0.176	1.52	20
Example 2	179	81	50	50	0.617	0.279	1.00	20
Example 3	154	56	25	50	0.446	0.162	2.00	0
Comparative Example 1	167	81	50	38	0.617	0.299	0.76	100
Reference Example 1	139	53	15	38	0.283	0.108	2.53	0
Reference Example 2	151	53	15	50	0.283	0.099	3.33	0
Reference Example 3	191	105	30	38	0.286	0.157	1.27	0
Reference Example 4	203	105	30	50	0.286	0.148	1.67	0

[0074] [Evaluation]

As is apparent from Table 1, it is found that according to each of Examples of the present invention, when the ratio T_{PSA}/T_{OL} is set to a predetermined value or less, or the ratio T_{SP}/T_{PSA} is set to a predetermined value or more, in the polarizing plate with retardation layers having a ratio T_{PSA}/T_{PWR} of 0.4 or more, the adhesive contamination at the time of the cutting of the

polarizing plate with retardation layers is significantly suppressed. Further, as is apparent from comparison between Example 2 and Comparative Example 1, when the ratio T_{PSA}/T_{OL} is about 0.3, the adhesive contamination occurs at a ratio of 100%, but when the ratio T_{PSA}/T_{OL} is about 0.28, the occurrence ratio of the adhesive contamination is drastically reduced to 20%. That is, it is found that a critical value is present at a ratio T_{PSA}/T_{OL} of around 0.29. In addition, as is apparent from each of Reference Examples, it is found that no adhesive contamination occurs in the polarizing plate with retardation layers having a ratio T_{PSA}/T_{PWR} of less than 0.4, and hence the adhesive contamination is a new problem in the polarizing plate with retardation layers having a ratio T_{PSA}/T_{PWR} of 0.4 or more.

Industrial Applicability

[0075] The polarizing plate with retardation layers obtained from the optical laminate of the present invention is suitably used as a circularly polarizing plate for each of a liquid crystal display apparatus, an organic EL display apparatus, and an inorganic EL display apparatus.

Reference Signs List

- [0076] **10** polarizing plate
- 11** polarizer
- 12** protective layer

21	first retardation layer
22	second retardation layer
31	first adhesive layer
32	second adhesive layer
40	pressure-sensitive adhesive layer
50	surface protective film
60	separator
70	polarizing plate with retardation layers
100	optical laminate

Claims

[Claim 1] An optical laminate, comprising:

a polarizing plate with retardation layers including

a polarizing plate including a polarizer and a protective layer arranged on at least a viewer side of the polarizer,

a first retardation layer bonded to a side of the polarizing plate opposite to a viewer side thereof via a first adhesive layer,

a second retardation layer bonded to the first retardation layer via a second adhesive layer, and

a pressure-sensitive adhesive layer arranged on a side of the second retardation layer opposite to the first retardation layer;

a surface protective film temporarily bonded to a viewer side of the polarizing plate with retardation layers in a peelable manner; and

a separator temporarily bonded to the pressure-sensitive adhesive layer of the polarizing plate with retardation layers in a peelable manner,

wherein when a thickness of the pressure-sensitive adhesive layer is represented by T_{PSA} , a thickness of the polarizing plate with retardation layers is represented by T_{PWR} , and a thickness of the optical laminate is represented by T_{OL} , the following relationships are satisfied:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{PSA}/T_{OL} \leq 0.29.$$

[Claim 2] An optical laminate, comprising:

a polarizing plate with retardation layers including

a polarizing plate including a polarizer and a protective layer arranged on at least a viewer side of the polarizer,

a first retardation layer bonded to a side of the polarizing plate opposite to a viewer side thereof via a first adhesive layer,

a second retardation layer bonded to the first retardation layer via a second adhesive layer, and

a pressure-sensitive adhesive layer arranged on a side of the second retardation layer opposite to the first retardation layer;

a surface protective film temporarily bonded to a viewer side of the polarizing plate with retardation layers in a peelable manner; and

a separator temporarily bonded to the pressure-sensitive adhesive layer of the polarizing plate with retardation layers in a peelable manner,

wherein when a thickness of the pressure-sensitive adhesive layer is represented by T_{PSA} , a thickness of the polarizing plate with retardation layers is represented by T_{PWR} ,

and a thickness of the separator is represented by T_{SP} , the following relationships are satisfied:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{SP}/T_{PSA} \geq 0.8.$$

[Claim 3] The optical laminate according to claim 1 or 2, wherein the T_{PSA} , the T_{PWR} , the T_{OL} , and the T_{SP} satisfy the following relationships:

$$T_{PSA}/T_{PWR} \geq 0.4$$

$$T_{PSA}/T_{OL} \leq 0.29$$

$$T_{SP}/T_{PSA} \geq 0.8.$$

[Claim 4] The optical laminate according to any one of claims 1 to 3, wherein the thickness T_{PSA} of the pressure-sensitive adhesive layer is 20 μm or more.

[Claim 5] The optical laminate according to any one of claims 1 to 4, wherein a thickness of the polarizer is 8 μm or less.

[Claim 6] The optical laminate according to any one of claims 1 to 5, wherein the pressure-sensitive adhesive layer has a storage modulus of elasticity at 25°C of from 1.0×10^4 Pa to 1.0×10^6 Pa.

[Claim 7] The optical laminate according to any one of claims 1 to 6, wherein the thickness T_{PWR} of the polarizing plate with

retardation layers is 100 μm or less.

[Claim 8] The optical laminate according to any one of claims 1 to 7, wherein the polarizing plate includes the protective layer only on the viewer side of the polarizer.

[Claim 9] The optical laminate according to any one of claims 1 to 8, wherein the first retardation layer and the second retardation layer are each an alignment fixed layer of a liquid crystal compound.

[Claim 10] The optical laminate according to claim 9,

wherein the first retardation layer has an $\text{Re}(550)$ of from 200 nm to 300 nm, and a slow axis thereof and an absorption axis of the polarizer form an angle of from 10° to 20° , and

wherein the second retardation layer has an $\text{Re}(550)$ of from 100 nm to 190 nm, and a slow axis thereof and the absorption axis of the polarizer form an angle of from 70° to 80° .

[Claim 11] An image display apparatus, comprising the polarizing plate with retardation layers of the optical laminate of any one of claims 1 to 10.

[Claim 12] The image display apparatus according to claim 11, wherein the image display apparatus is an organic

electroluminescence display apparatus.