

Description

Title of Invention: METHOD FOR MANUFACTURING PHASE DIFFERENCE
LAYER-EQUIPPED POLARIZING PLATE

Technical Field

[0001] The present invention relates to a method of producing a polarizing plate with a retardation layer.

Background Art

[0002] 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 obtained by integrating the polarizing plate and the retardation plate with each other has been widely used (for example, Patent Literature 1). In recent years, investigations have been made on the possibility of curving, bending, folding, or winding of the image display apparatus through use of a flexible substrate (e.g., a resin substrate). As a polarizing plate with a retardation layer to be used in such image display apparatus, a thin polarizing plate with a retardation layer has been demanded. However, the thin polarizing plate with a retardation layer has a problem in

that warping is liable to 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-mentioned problem of the related art, and a primary object of the present invention is to provide a polarizing plate with a retardation layer, which is suppressed from causing warping, in high yield.

Solution to Problem

[0005] According to an embodiment of the present invention, there is provided a method of producing a polarizing plate with a retardation layer. The production method includes: preparing a laminate including a first protective film, a polarizing plate including a polarizer and a protective layer arranged on at least one side of the polarizer, a retardation layer, and a second protective film in the stated order, having a total of a thickness of the polarizing plate and a thickness of the retardation layer of 50 μm or less, and having a ratio of the thickness of the polarizing plate to the thickness of the

retardation layer of 5 or more; and placing the laminate under an environment having a water vapor amount of 10.5 g/m^3 or more under a state in which the laminate is placed on a placement surface, to thereby subject the laminate to humidifying treatment, wherein the placing is performed under a state in which a main surface of the laminate has an angle with respect to the placement surface.

In one embodiment, the production method includes laminating the polarizing plate and the retardation layer to obtain a laminate precursor.

In one embodiment, the production method includes cutting the laminate precursor into a sheet shape.

In one embodiment, the humidifying treatment is performed under a state in which a plurality of the laminates are arranged next to each other.

In one embodiment, the first protective film has a moisture permeability at 40°C and 92%RH of $30 \text{ g/m}^2 \cdot 24 \text{ h}$ or less.

In one embodiment, the second protective film has a moisture permeability at 40°C and 92%RH of $30 \text{ g/m}^2 \cdot 24 \text{ h}$ or less.

In one embodiment, the production method includes laminating the polarizing plate and the retardation layer while roll conveying the polarizing plate and the retardation layer.

In one embodiment, the production method includes laminating the polarizing plate and the retardation layer with an active energy ray-curable adhesive.

In one embodiment, the active energy ray-curable adhesive has a thickness after curing of 0.4 μm or more.

In one embodiment, the laminate includes a pressure-sensitive adhesive layer arranged on a side of the retardation layer on which the polarizing plate is prevented from being arranged, and a laminated portion of the polarizing plate, the retardation layer, and the pressure-sensitive adhesive layer has an increase in weight per unit area of 0.1% or more through the humidifying treatment.

In one embodiment, a period of time of the humidifying treatment is 6 hours or more.

In one embodiment, the water vapor amount at a time of the humidifying treatment is from 10.5 g/m^3 to 30 g/m^3 .

In one embodiment, the production method includes laminating the polarizing plate and the retardation layer under an environment having a water vapor amount of 10.2 g/m^3 or less.

In one embodiment, the water vapor amount at a time of the humidifying treatment is higher than a water vapor amount at a time of laminating the polarizing plate and the retardation layer by 0.5 g/m^3 or more.

In one embodiment, the retardation layer or the protective layer has a moisture permeability at 40°C and 92%RH of $300 \text{ g/m}^2 \cdot 24 \text{ h}$ or more.

In one embodiment, the polarizing plate has the protective layer arranged only on a side of the polarizer on which the retardation layer is prevented from being arranged.

In one embodiment, a center of gravity of the polarizer in a thickness direction is positioned on a retardation layer side with respect to a center of gravity of a laminated portion of the polarizing plate and the retardation layer in a thickness direction.

In one embodiment, the retardation layer is an alignment fixed layer of a liquid crystal compound.

Advantageous Effects of Invention

[0006] According to the embodiment of the present invention, the laminate including the first protective film, the polarizing plate, the retardation layer, and the second protective film in the stated order is subjected to the humidifying treatment under predetermined conditions. Thus, the polarizing plate with a retardation layer, which is suppressed from causing warping, can be produced in high yield even when the polarizing plate and the retardation layer have predetermined thicknesses.

Brief Description of Drawings

[0007] FIG. 1 is a schematic sectional view for illustrating a schematic configuration of a laminate according to a first embodiment of the present invention.

FIG. 2 is a schematic sectional view for illustrating a schematic configuration of a laminate according to a second embodiment of the present invention.

FIG. 3 is a sectional view for illustrating an example of a warping state of a laminate precursor.

FIG. 4 is a sectional view for illustrating an example of a laminated portion from a polarizing plate to a pressure-

sensitive adhesive layer.

FIG. 5 is a sectional view for illustrating an example of a state in which the laminate is placed on a placement surface.

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)

" $Re(\lambda)$ " 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 $Re(\lambda)$ is determined from the equation " $Re(\lambda)=(n_x-n_y)\times d$ " when the thickness of a layer (film) is represented by "d" (nm).

(3) Thickness Direction Retardation (R_{th})

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

(4) N_z Coefficient

An N_z coefficient is determined from the equation " $N_z=R_{th}/Re$ ".

(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. Accordingly, for example, the term " 45° " means $\pm 45^\circ$.

[0010] A method of producing a polarizing plate with a retardation layer according to one embodiment of the present

invention includes: preparing a laminate including a polarizing plate including a polarizer, and a retardation layer; and placing the laminate under a predetermined environment under a state in which the laminate is placed on a placement surface.

[0011] A. Laminate

FIG. 1 is a schematic sectional view for illustrating a schematic configuration of a laminate according to a first embodiment of the present invention. A laminate **100** includes a first protective film **31**, a polarizing plate **10**, a retardation layer **20**, and a second protective film **32** in the stated order from a viewer side. In the illustrated example, the polarizing plate **10** includes a polarizer **11** and a protective layer **12** arranged on the viewer side of the polarizer **11** (the side on which the retardation layer **20** is prevented from being arranged), and no protective layer is arranged between the polarizer **11** and the retardation layer **20**. According to such embodiment, for example, a thickness of the polarizing plate, a total thickness, and a thickness ratio described later can be satisfactorily achieved. Typically, the center of gravity of the polarizer in a thickness direction is positioned on a retardation layer side with respect to the center of gravity of a laminated portion of the polarizing plate and the retardation layer in a thickness direction.

[0012] Although not shown, the polarizing plate **10** may further include a protective layer on the other side of the polarizer **11** (between the polarizer **11** and the retardation layer **20**).

[0013] FIG. **2** is a schematic sectional view for illustrating a schematic configuration of a laminate according to a second embodiment of the present invention. While the retardation layer **20** is arranged as a single layer in the above-mentioned first embodiment, the retardation layer **20** has a laminated structure including a first retardation layer **21** and a second retardation layer **22** in the second embodiment. Unlike the case of the illustrated example, the retardation layer **20** may have a laminated structure of three or more layers.

[0014] Although not shown, the laminate may further include any other functional layer. The kinds, characteristics, number, combination, arrangement, and the like of the functional layers that may be included in the laminate may be appropriately set in accordance with purposes. For example, the laminate may further include a conductive layer or an isotropic substrate with a conductive layer. The conductive layer or the isotropic substrate with a conductive layer is typically arranged between the retardation layer **20** and the second protective film **32**. The laminate (polarizing plate with a retardation layer) including

the conductive layer or the isotropic substrate with a conductive layer is applied to, for example, a so-called inner touch panel-type input and display apparatus in which a touch sensor is incorporated in an inside of an image display panel. As another example, the laminate may further include any other retardation layer. The optical characteristics (e.g., refractive index characteristic, in-plane retardation, Nz coefficient, and photoelastic coefficient), thickness, arrangement, and the like of the other retardation layer may be appropriately set in accordance with purposes. As a specific example, any other retardation layer for improving viewability when a display screen is viewed through a pair of polarized sunglasses (typically a layer for imparting a circular (elliptical) polarization function or a layer for imparting an ultra-high retardation) may be arranged on the viewer side of the polarizer **11**. When such layer is included, even in the case where the display screen is viewed through a polarizing lens such as a pair of polarized sunglasses, excellent viewability can be achieved. Accordingly, a polarizing plate with a retardation layer to be obtained is suitably applicable even to an image display apparatus that may be used outdoors.

[0015] The members for forming the laminate may be laminated on each other via any appropriate adhesion layer (not shown). Specific examples of the adhesion layer include an adhesive layer

and a pressure-sensitive adhesive layer. For example, the first protective film **31** is bonded to the polarizing plate **10** via a pressure-sensitive adhesive layer. The first protective film **31** may be peeled before a polarizing plate with a retardation layer to be obtained according to the embodiment of the present invention is used (before the polarizing plate with a retardation layer is laminated on an image display panel) or in a production process for a final product (image display apparatus), or may be directly installed in the final product.

[0016] For example, the second protective film **32** is bonded to the retardation layer **20** via a pressure-sensitive adhesive layer. In practical use, the second protective film **32** may function as a release film (separator) that is temporarily attached to the retardation layer **20** before a polarizing plate with a retardation layer to be obtained according to the embodiment of the present invention is used. When the release film is temporarily attached, for example, the pressure-sensitive adhesive layer is protected, and the roll forming of the laminate can be performed.

[0017] For example, the retardation layer **20** is bonded to the polarizing plate **10** via an adhesive layer (preferably with an active energy ray-curable adhesive). When the retardation layer **20** has a laminated structure of two or more layers, the

respective retardation layers are bonded to each other via an adhesive layer (preferably with an active energy ray-curable adhesive).

[0018] A-1. Polarizing Plate

The polarizing plate includes the polarizer and the protective layer. The thickness of the polarizing plate is preferably 20 μm or more, more preferably 25 μm or more, though the thickness varies depending on the number of the protective layers to be included. Meanwhile, the thickness of the polarizing plate is preferably 40 μm or less, more preferably 36 μm or less, still more preferably 33 μm or less. When the adhesion layer is used at the time of the lamination of the polarizer and the protective layer, the thickness of the adhesion layer is not included in the thickness of the polarizing plate.

[0019] The polarizer is typically a resin film containing a dichroic substance (e.g., iodine). Examples of the resin film include hydrophilic polymer films, such as a polyvinyl alcohol (PVA)-based film, a partially formalized PVA-based film, and an ethylene-vinyl acetate copolymer-based partially saponified film.

[0020] The thickness of the polarizer is preferably 15 μm or less, more preferably 12 μm or less, still more preferably 10 μm or less. Meanwhile, the thickness of the polarizer is

preferably 1 μm or more.

[0021] 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, for example, from 41.5% to 46.0%, preferably from 42.0% to 46.0%, 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.

[0022] The protective layer may be formed of any appropriate film that may be used as a protective layer of the polarizer. Specific examples of the material serving as a main component of the film include cellulose-based resins such as triacetyl cellulose (TAC), and transparent resins, such as polyester-based, polyvinyl alcohol-based, polycarbonate-based, polyamide-based, polyimide-based, polyethersulfone-based, polysulfone-based, polystyrene-based, cycloolefin-based (e.g., polynorbornene-based), polyolefin-based, (meth)acrylic, and acetate-based resins.

[0023] A polarizing plate with a retardation layer to be obtained according to the embodiment of the present invention is typically arranged on the viewer side of an image display apparatus, and the protective layer **12** is arranged on the viewer

side. Accordingly, the protective layer **12** may be subjected to surface treatment, such as hard coat (HC) treatment, antireflection treatment, anti-sticking treatment, or antiglare treatment, as required.

[0024] 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 the surface treatment, its thickness is a thickness including the thickness of the surface-treated layer.

[0025] In one embodiment, it is preferred that the protective layer (not shown) arranged between the polarizer **11** and the retardation layer **20** 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 protective layer arranged between the polarizer **11** and the retardation layer **20** 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 .

[0026] The polarizing plate may be produced by any appropriate method. Specifically, the polarizing plate may

include a polarizer produced from a single-layer resin film, or may include a polarizer obtained by using a laminate of two or more layers.

[0027] A method of producing the polarizer from the single-layer resin film typically includes subjecting the resin film to dyeing treatment with a dichroic substance, such as iodine or a dichroic dye, and stretching treatment. As the resin film, there is used, for example, 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. The method may further include insolubilizing treatment, swelling treatment, cross-linking treatment, or the like. The polarizing plate may be obtained by laminating the protective layer on at least one side of the obtained polarizer. Such production method is well known and commonly used in the art, and hence detailed description thereof is omitted.

[0028] A specific example of the polarizer obtained by using the above-mentioned laminate is 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, for example, by: applying a PVA-based resin solution to 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, a polyvinyl alcohol-based resin layer containing a halide and a polyvinyl alcohol-based resin is preferably formed on one side of the resin substrate. The stretching typically includes stretching the laminate under a state in which the laminate is immersed in an aqueous solution of boric acid. Further, the stretching may further include in-air 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. In addition, in this embodiment, the laminate is preferably subjected to drying shrinkage treatment, which includes heating the laminate, while conveying the laminate in a lengthwise direction thereof, to shrink the laminate by 2% or more in a widthwise direction thereof. The production method of this embodiment typically includes subjecting the laminate to in-air auxiliary stretching treatment, dyeing treatment, underwater stretching treatment, and drying shrinkage treatment in the stated order. When the auxiliary stretching is introduced, even in the case where PVA

is applied onto a thermoplastic resin, the crystallinity of PVA can be improved, and hence high optical characteristics can be achieved. In addition, when the alignment property of PVA is improved in advance simultaneously with the crystallinity improvement, problems, such as a reduction in alignment property of PVA and the dissolution thereof, can be prevented at the time of the immersion of the laminate in water in the subsequent dyeing step or stretching step, and hence high optical characteristics can be achieved. Further, in the case where the PVA-based resin layer is immersed in a liquid, the disturbance of the alignment of the molecules of polyvinyl alcohol and reductions in alignment properties thereof can be suppressed as compared to those in the case where the PVA-based resin layer is free of any halide. Thus, the optical characteristics of the polarizer to be obtained through treatment steps performed by immersing the laminate in a liquid, such as the dyeing treatment and the underwater stretching treatment, can be improved. Further, the optical characteristics can be improved by shrinking the laminate in its widthwise direction through the drying shrinkage treatment. The resultant laminate of the resin substrate and the polarizer may be used as it is (that is, the resin substrate may be used as a protective layer of the polarizer), or may be used by laminating any appropriate protective layer in accordance with purposes on the peeled surface on which the resin substrate has been peeled from the

laminate of the resin substrate and the polarizer, or on a surface on an opposite side to the peeled surface. Details about such method of producing the polarizer are described in, for example, JP 2012-73580 A or JP 6470455 B1, the description of which is incorporated herein by reference in its entirety.

[0029] A-2. Retardation Layer

The thickness of the retardation layer is preferably 8 μm or less, more preferably 5 μm or less, though the thickness varies depending on the configuration of the retardation layer (whether the retardation layer is a single layer or has a laminated structure). Meanwhile, the thickness of the retardation layer is, for example, 1 μm or more. When the retardation layer has the laminated structure, the "thickness of the retardation layer" means the total thickness of the respective retardation layers. Specifically, the thickness of the adhesion layer is not included in the "thickness of the retardation layer."

[0030] An alignment fixed layer of a liquid crystal compound (liquid crystal alignment fixed layer) is preferably used as the retardation layer. When the liquid crystal compound is used, a difference between the n_x and 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. Accordingly, significant thinning of the polarizing plate with a retardation layer 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 the retardation layer, 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 retardation layer (homogeneous alignment).

[0031] 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. 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.

[0032] 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 in accordance with the alignment treatment direction of the surface of the substrate.

[0033] 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 a polymerizable monomer or a 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.

[0034] Specific examples of the liquid crystal compound and

details about the method of forming the alignment fixed layer are described in JP 2006-163343 A, the description of which is incorporated herein by reference.

[0035] As described above, the retardation layer **20** may be a single layer, or may have a laminated structure of two or more layers.

[0036] In one embodiment in which the retardation layer **20** is a single layer as illustrated in FIG. **1**, the retardation layer **20** may function as a $\lambda/4$ plate. Specifically, the $\text{Re}(550)$ of the retardation layer is preferably from 100 nm to 180 nm, more preferably from 110 nm to 170 nm, still more preferably from 110 nm to 160 nm. The thickness of the retardation layer may be adjusted so that the desired in-plane retardation of the $\lambda/4$ plate may be obtained. When the retardation layer is the above-mentioned liquid crystal alignment fixed layer, the thickness thereof is, for example, from 1.0 μm to 2.5 μm . In this embodiment, an angle formed by the slow axis of the retardation layer and the absorption axis of the polarizer is preferably from 40° to 50° , more preferably from 42° to 48° , still more preferably from 44° to 46° . In this embodiment, the retardation layer preferably shows such a reverse wavelength dispersion characteristic that its retardation value increases with an increase in wavelength of measurement light. In this embodiment,

the laminate may further include a layer (the other retardation layer, not shown) showing a refractive index characteristic of $n_z > n_x = n_y$ arranged between the retardation layer **20** and the second protective film **32**.

[0037] In another embodiment in which the retardation layer **20** is a single layer, the retardation layer **20** may function as a $\lambda/2$ plate. Specifically, the $\text{Re}(550)$ of the retardation layer is preferably from 200 nm to 300 nm, more preferably from 230 nm to 290 nm, still more preferably from 230 nm to 280 nm. The thickness of the retardation layer may be adjusted so that the desired in-plane retardation of the $\lambda/2$ plate may be obtained. When the retardation layer is the above-mentioned liquid crystal alignment fixed layer, the thickness thereof is, for example, from 2.0 μm to 4.0 μm . In this embodiment, an angle formed by the slow axis of the retardation layer and the absorption axis of the polarizer is preferably from 10° to 20° , more preferably from 12° to 18° , still more preferably from 12° to 16° .

[0038] When the retardation layer **20** has a laminated structure as illustrated in FIG. **2**, for example, the retardation layer **20** has a laminated structure of two layers in which the first retardation layer (H layer) **21** and the second retardation layer (Q layer) **22** are arranged in the stated order from a polarizing plate side. The H layer may typically function as a

$\lambda/2$ plate, and the Q layer may typically function as a $\lambda/4$ plate. Specifically, the Re(550) of the H layer is preferably from 200 nm to 300 nm, more preferably from 220 nm to 290 nm, still more preferably from 230 nm to 280 nm, and the Re(550) of the Q layer is preferably from 100 nm to 180 nm, more preferably from 110 nm to 170 nm, still more preferably from 110 nm to 150 nm. The thickness of the H layer may be adjusted so that the desired in-plane retardation of the $\lambda/2$ plate may be obtained. When the H layer is the above-mentioned liquid crystal alignment fixed layer, the thickness thereof is, for example, from 2.0 μm to 4.0 μm . The thickness of the Q layer may be adjusted so that the desired in-plane retardation of the $\lambda/4$ plate may be obtained. When the Q layer is the above-mentioned liquid crystal alignment fixed layer, the thickness thereof is, for example, from 1.0 μm to 2.5 μm . In this embodiment, an angle formed by the slow axis of the H layer and the absorption axis of the polarizer is preferably from 10° to 20° , more preferably from 12° to 18° , still more preferably from 12° to 16° , and an angle formed by the slow axis of the Q layer and the absorption axis of the polarizer is preferably from 70° to 80° , more preferably from 72° to 78° , still more preferably from 72° to 76° . When the retardation layer **20** has the laminated structure, the respective layers (e.g., the H layer and the Q layer) may each show such a reverse wavelength dispersion characteristic that its retardation value increases with an increase in wavelength of

measurement light, such a positive wavelength dispersion characteristic that the retardation value reduces with an increase in wavelength of the measurement light, or such a flat wavelength dispersion characteristic that the retardation value remains substantially unchanged even when the wavelength of the measurement light changes.

[0039] The refractive index characteristic of the retardation layer **20** (each layer when the retardation layer **20** has the laminated structure) 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. The N_z coefficient of the retardation layer is preferably from 0.9 to 1.5, more preferably from 0.9 to 1.3.

[0040] As described above, the retardation layer is preferably a 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.

[0041] 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.

[0042] 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.

[0043] 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 a nematic liquid crystal monomer.

[0044] A-3. Relationship between Thickness of Polarizing Plate and Thickness of Retardation Layer

The total of the thickness of the polarizing plate and the thickness of the retardation layer (sometimes referred to simply as "total thickness") is 50 μm or less, preferably 45 μm or less, more preferably 40 μm or less. Meanwhile, the total thickness

is, for example, 25 μm or more.

[0045] A ratio of the thickness of the polarizing plate to the thickness of the retardation layer (the thickness of the polarizing plate/the thickness of the retardation layer, sometimes referred to simply as "thickness ratio") is 5 or more, preferably 8 or more, more preferably 10 or more. Meanwhile, the thickness ratio is preferably 30 or less, more preferably 25 or less.

[0046] The laminate to be used in the production method according to the embodiment of the present invention can be said to have a small total thickness, and have a high ratio of the thickness of the polarizing plate (a low ratio of the thickness of the retardation layer) to the total thickness. The inventors of the present invention have found that, when the total thickness and the thickness ratio fall within the above-mentioned predetermined ranges, the warping problem described above is liable to occur. More specifically, when a difference between the thickness of the polarizing plate and the thickness of the retardation layer is not large, and when the thickness of the polarizing plate is excessively large, the warping problem is less liable to occur in the polarizing plate with a retardation layer. The inventors of the present invention have made extensive investigations on suppression of the warping

based on such new finding, and as a result, have found that the warping can be efficiently suppressed by the production method of the embodiment of the present invention.

[0047] A-4. First Protective Film

The first protective film **31** may be formed of any appropriate material. Specific examples of the material for forming the film 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.

[0048] The first protective film has a moisture permeability at 40°C and 92%RH of preferably 30 g/m²·24 h or less, more preferably 20 g/m²·24 h or less. According to such first protective film, moisture is appropriately imparted to the laminate (preferably the polarizer) in humidifying treatment described later, and a polarizing plate with a retardation layer that is suppressed from causing warping can be obtained. Meanwhile, the first protective film has a moisture permeability at 40°C and 92%RH of, for example, 5 g/m²·24 h or more.

[0049] The thickness of the first protective film is preferably from 15 μm to 50 μm , more preferably from 25 μm to 40 μm .

[0050] As described above, the first protective film **31** may be bonded to the polarizing plate **10** via a pressure-sensitive adhesive layer. Any appropriate configuration may be adopted as the 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 may 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 (specifically, the pressure-sensitive adhesive layer preferably includes the acrylic pressure-sensitive adhesive). The thickness of the

pressure-sensitive adhesive layer is, for example, from 5 μm to 15 μm . The storage modulus of elasticity of the pressure-sensitive adhesive layer at 25°C is, for example, from 1.0×10^5 Pa to 1.0×10^7 Pa.

[0051] In one embodiment, a laminated product (hereinafter referred to as "surface protective film") obtained by forming the pressure-sensitive adhesive layer in advance on the first protective film is used. The thickness of the surface protective film is preferably from 30 μm to 60 μm , more preferably from 30 μm to 50 μm . When the first protective film is peeled as described above, the first protective film may be peeled together with the pressure-sensitive adhesive layer (as the whole surface protective film).

[0052] A-5. Second Protective Film

The second protective film **32** may include any appropriate plastic film. Specific examples of the plastic film include a polyethylene terephthalate (PET) film, a polyethylene film, and a polypropylene film. As described above, the second protective film **32** may function as a separator. Specifically, a plastic film whose surface is coated with a release agent is preferably used as the second protective film **32**. Specific examples of the release agent include a silicone-based peeling agent, a fluorine-based release agent, and a long-chain alkyl acrylate-

based release agent.

[0053] The second protective film has a moisture permeability at 40°C and 92%RH of preferably 30 g/m²·24 h or less, more preferably 20 g/m²·24 h or less. According to such second protective film, moisture is appropriately imparted to the laminate (preferably the polarizer) in humidifying treatment described later, and a polarizing plate with a retardation layer that is suppressed from causing warping can be obtained. Meanwhile, the second protective film has a moisture permeability at 40°C and 92%RH of, for example, 5 g/m²·24 h or more.

[0054] The thickness of the second protective film is preferably from 20 μm to 80 μm, more preferably from 35 μm to 55 μm.

[0055] A-6. Production of Laminate

The laminate **100** may be obtained, for example, by laminating the polarizing plate **10** and the retardation layer **20** on each other to produce a laminate precursor, and laminating the first protective film **31** and the second protective film **32** on the resultant laminate precursor.

[0056] For example, the lamination of the polarizing plate

10 and the retardation layer **20** is performed while the polarizing plate **10** and the retardation layer **20** are roll conveyed (in a so-called roll-to-roll manner). The lamination is typically performed by transferring a liquid crystal alignment fixed layer formed on a substrate. When the retardation layer has a laminated structure as illustrated in FIG. **2**, the respective retardation layers may be sequentially laminated (transferred) on the polarizing plate, or a laminated product of the retardation layers may be laminated (transferred) on the polarizing plate.

[0057] The transfer is performed with, for example, an active energy ray-curable adhesive. The thickness of the active energy ray-curable adhesive (the thickness of the adhesive layer) after curing is preferably 0.4 μm or more, more preferably from 0.4 μm to 3.0 μm , still more preferably from 0.6 μm to 1.5 μm . The warping of the polarizing plate with a retardation layer having the above-mentioned predetermined total thickness and thickness ratio is attributed mainly to the adhesive (specifically, shrinkage of the active energy ray-curable adhesive at the time of curing) used for the lamination of the polarizing plate and the retardation layer, and the warping may occur in the laminate precursor obtained by laminating the polarizing plate **10** and the retardation layer **20** on each other.

[0058] FIG. 3 is a sectional view for illustrating an example of a warping state of the laminate precursor. In FIG. 3, hatching is omitted in a cross section of the laminate precursor for ease of viewing of the drawing. In the example illustrated in FIG. 3, convex warping occurs on the polarizing plate 10 side of a laminate precursor 90. The warping tends to occur along the absorption axis direction of the polarizing plate 10 (polarizer 11).

[0059] The lamination of the polarizing plate 10 and the retardation layer 20 is preferably performed under an environment having a water vapor amount (A1) of 10.2 g/m³ or less. The water vapor amount (A1) at the time of the lamination is more preferably from 6.0 g/m³ to 10.0 g/m³, still more preferably from 8.0 g/m³ to 9.5 g/m³. When the lamination is performed under an environment having a water vapor amount (A1) falling within such ranges, for example, effects exhibited by humidifying treatment described later become significant. Such water vapor amount (A1) at the time of the lamination may be achieved, for example, by changing the relative humidity of the environment in accordance with the temperature thereof in the temperature range of from 18°C to 25°C. The water vapor amount (A1) may be achieved as follows: for example, when the temperature is 18°C, the water vapor amount (A1) may be achieved by setting the relative humidity to 65%RH or less; for example,

when the temperature is 20°C, the water vapor amount (A1) may be achieved by setting the relative humidity to 55%RH or less; and, for example, when the temperature is 23°C, the water vapor amount (A1) may be achieved by setting the relative humidity to 45%RH or less. The lower limit of the relative humidity may be, for example, 30%RH.

[0060] In one embodiment, any one of the protective layer **12** and the retardation layer **20** has a moisture permeability at 40°C and 92%RH of preferably 300 g/m²·24 h or more, more preferably from 400 g/m²·24 h to 1,000 g/m²·24 h, still more preferably from 400 g/m²·24 h to 800 g/m²·24 h. When any one of the protective layer **12** and the retardation layer **20** has such moisture permeability, effects exhibited by humidifying treatment described later can become significant.

[0061] When the laminate further includes any other functional layer (e.g., the conductive layer or the other retardation layer) as described above, the functional layer may be laminated or formed at a predetermined position by any appropriate method.

[0062] The lamination of: the laminate precursor including at least the polarizing plate **10** and the retardation layer **20**; and the first protective film **31** is performed, for example, by

bonding the above-mentioned surface protective film to the laminate precursor. The lamination of the laminate precursor and the second protective film **32** is performed, for example, with a pressure-sensitive adhesive. The thickness of the pressure-sensitive adhesive (the thickness of a pressure-sensitive adhesive layer arranged between the retardation layer **20** and the second protective film **32**) is, for example, from 10 μm to 20 μm .

[0063] B. Humidifying Treatment

The above-mentioned laminate is subjected to humidifying treatment. When the laminate is subjected to the humidifying treatment, moisture is imparted to the laminate (preferably the polarizer), and thus a polarizing plate with a retardation layer that is suppressed from causing warping can be obtained. The humidifying treatment is performed, for example, by placing the laminate under an environment having a water vapor amount of 10.5 g/m³ or more. A water vapor amount (A2) at the time of the humidifying treatment is preferably from 10.5 g/m³ to 30 g/m³, more preferably from 11 g/m³ to 20 g/m³.

[0064] The water vapor amount (A2) at the time of the humidifying treatment may be achieved as follows: for example, when the temperature is 18°C, the water vapor amount (A2) may be achieved by setting the relative humidity to 80%RH or more; for

example, when the temperature is 20°C, the water vapor amount (A2) may be achieved by setting the relative humidity to 60%RH or more; and, for example, when the temperature is 23°C, the water vapor amount (A2) may be achieved by setting the relative humidity to 50%RH or more. The upper limit of the relative humidity may be, for example, 100%RH.

[0065] In one embodiment, the laminate is subjected to the humidifying treatment under an environment that satisfies a larger water vapor amount than the above-mentioned water vapor amount (A1). More specifically, a difference between the water vapor amount (A2) at the time of the humidifying treatment and the water vapor amount (A1) is preferably 0.5 g/m³ or more, more preferably from 1.0 g/m³ to 28 g/m³, still more preferably from 1.0 g/m³ to 12 g/m³, particularly preferably from 1.5 g/m³ to 10 g/m³, most preferably from 1.5 g/m³ to 8 g/m³. When the laminate is humidified under such conditions, an appropriate amount of moisture can be imparted to the laminate. More specifically, the moisture can be imparted to the laminate without any shrinkage of the laminate. When the amount of the moisture imparted to the laminate is excessively large in the humidifying treatment, for example, warping that is convex in a reverse direction with respect to initial warping and/or in-plane warping in a direction perpendicular to the direction of the initial warping occurs in some cases.

[0066] In one embodiment, the laminate is preferably subjected to the humidifying treatment so that the weight of a laminated portion from the polarizing plate to the pressure-sensitive adhesive layer per unit area is increased by 0.1% or more. The increase in weight of the laminated portion from the polarizing plate to the pressure-sensitive adhesive layer per unit area through the humidifying treatment is more preferably from 0.1% to 2.0%, still more preferably from 0.1% to 1.0%, particularly preferably from 0.1% to 0.5%. When the increase in weight is set within such ranges, the polarizer can absorb a desired amount of moisture. As a result, a polarizing plate with a retardation layer to be obtained can be effectively suppressed from causing warping. Herein, for example, as illustrated in FIG. 4, the laminated portion from the polarizing plate to the pressure-sensitive adhesive layer refers to a laminated portion **80** of the polarizing plate **10**, an adhesive layer **40**, the retardation layer **20** (when the retardation layer **20** has a laminated structure, the adhesive layer is included), and a pressure-sensitive adhesive layer **50**. In FIG. 4, hatching is omitted in a cross section of the laminated portion.

[0067] The period of time of the humidifying treatment is preferably 6 hours or more, more preferably 12 hours or more, still more preferably 24 hours or more. According to such period

of time of the treatment, for example, the above-mentioned desired increase in weight (moisture absorption) can be satisfactorily achieved. Meanwhile, the period of time of the humidifying treatment is, for example, 150 hours or less. Even when the period of time of the humidifying treatment is excessively prolonged, the effects are not changed. Accordingly, the upper limit of the period of time of the humidifying treatment may be determined based on balance between the desired increase in weight and production efficiency.

[0068] At the time of the humidifying treatment, the laminate is placed on a placement surface under a state in which the main surface of the laminate has an angle with respect to the placement surface. FIG. 5 is a sectional view for illustrating an example of a state in which the laminate is placed on the placement surface. In FIG. 5, hatching is omitted in a cross section of the laminate for ease of viewing of the drawing. In the illustrated example, the laminate **100** is placed on a placement surface **S** so that a main surface **100a** of the laminate **100** has an angle θ with respect to the placement surface **S**. The angle θ is more than 0° and 90° or less, preferably from 70° to 90° , more preferably from 80° to 90° .

[0069] In addition, in the illustrated example, "n" laminates **100** each having a sheet shape are arranged next to

each other so that the main surfaces of the adjacent laminates **100** are overlapped with each other. Typically, the laminate is formed into a sheet shape having a predetermined size in advance of the humidifying treatment. The laminate having a sheet shape is preferably obtained by cutting a laminate precursor having an elongate shape. Specifically, the laminate having a sheet shape is preferably obtained by cutting the laminate precursor having an elongate shape to provide a laminate precursor having a sheet shape, followed by laminating the first protective film and the second protective film on the laminate precursor having a sheet shape. According to such embodiment, for example, a large roll conveyance (roll-to-roll) facility is not required, and hence an improvement in production efficiency can be achieved. The cutting is preferably performed on the laminate precursor in which warping occurs so that the laminates each having a sheet shape to be obtained may be overlapped with each other as illustrated in FIG. 5. In one embodiment, the laminate precursor having an elongate shape is cut in a direction of 45° with respect to the lengthwise direction thereof. In another embodiment, the laminate precursor having an elongate shape is cut in the lengthwise direction and width direction (direction perpendicular to the lengthwise direction) thereof.

[0070] According to such embodiment, the laminate (polarizer) is caused to efficiently absorb moisture, and a

polarizing plate with a retardation layer that is suppressed from causing warping can be produced in high yield. Specifically, when a state in which the main surface of the laminate has an angle with respect to the placement surface is adopted, as illustrated in FIG. 5, the humidifying treatment can be performed on a plurality of the laminates at once and under a uniform state (e.g., under a state in which uniform force is applied to the laminates). As a result, moisture can be uniformly imparted to the plurality of laminates (e.g., the above-mentioned increase in weight of the laminated portion of the polarizing plate and the retardation layer can be satisfactorily achieved in each of the plurality of laminates through the one-time humidifying treatment), and the polarizing plate with a retardation layer that is suppressed from causing warping can be produced in high yield. In addition, the polarizing plate with a retardation layer to be obtained may be excellent in external appearance.

Examples

[0071] The present invention is specifically described below by way of Examples. However, the present invention is not limited to these Examples. A thickness and a moisture permeability are values measured by the following measurement methods. In addition, the terms "part(s)" and "%" in Examples and Comparative Examples are by weight unless otherwise stated.

<Thickness>

A thickness of 10 μm or less was measured with a scanning electron microscope (manufactured by JEOL Ltd., product name: "JSM-7100F"). A thickness of more than 10 μm was measured with a digital micrometer (manufactured by Anritsu Corporation, product name: "KC-351C").

<Moisture Permeability>

A moisture permeability was determined by a dish method (JIS Z 0208).

[0072] [Example 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).

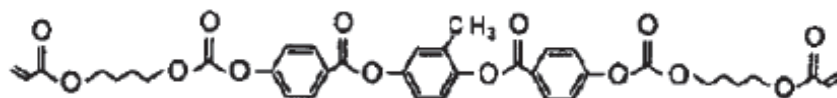
After that, the laminate was brought into contact with a SUS-made heating roll whose surface temperature was kept at about 75°C while being heated in an oven kept at about 90°C (drying shrinkage treatment).

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

[0073] A HC-COP film (thickness: 27 μm) was bonded as a protective layer to the polarizer side of the resultant laminate via a UV light-curable adhesive. The HC-COP film was a film including a cycloolefin-based resin (COP) film (thickness: 25 μm) and a HC layer (thickness: 2 μm) formed on the COP film, and was bonded to the laminate so that the COP film was on the polarizer side. Next, the resin substrate was peeled from the polarizer. Thus, a polarizing plate having the configuration "HC-COP film (protective layer)/polarizer" was obtained.

[0074] (Production of Retardation Layer)

10 g of a polymerizable liquid crystal compound showing a nematic liquid crystal phase (manufactured by BASF SE: product name: "Paliocolor LC242," represented by the following 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).



[0075] 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 $1 \text{ mJ}/\text{cm}^2$ 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 (H layer) was formed on the PET film. The liquid crystal alignment fixed layer A had a thickness of $2.5 \mu\text{m}$ and an in-plane retardation $\text{Re}(550)$ of 270 nm. Further, the liquid crystal alignment fixed layer A showed a refractive index characteristic of $n_x > n_y = n_z$.

[0076] A liquid crystal alignment fixed layer B (Q layer) 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 1.5 μm and an in-plane retardation $\text{Re}(550)$ of 140 nm. Further, the liquid crystal alignment fixed layer B showed a refractive index characteristic of $n_x > n_y = n_z$.

[0077] (Production of Laminate)

The resultant liquid crystal alignment fixed layer A (H layer) and liquid crystal alignment fixed layer B (Q layer) were transferred in the stated order onto the polarizer side of the resultant polarizing plate. 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 was performed via a UV-curable adhesive (thickness: 1.0 μm). Thus, a laminate precursor was obtained. The transfer (bonding) was performed while the polarizing plate and the liquid crystal alignment fixed layers were roll conveyed. Further, the transfer (bonding) was performed under an environment (at 23°C and 45%RH) having a water vapor amount of 9.3 g/m³.

The resultant laminate precursor had a total thickness of 36 μm and a thickness ratio of 8.

[0078] The resultant laminate precursor having an elongate shape was cut in a direction of 45° with respect to the lengthwise direction and width direction (direction perpendicular to the lengthwise direction) thereof to provide a laminate precursor having a sheet shape and measuring 165 mm by 80 mm. The lengthwise direction corresponds to the absorption axis direction of the polarizer.

[0079] Next, a surface protective film (thickness: 48 μm) was bonded to the protective layer side of the polarizing plate of the laminate precursor. The surface protective film was a film including a PET-based film (thickness: 38 μm , moisture permeability: 18 $\text{g}/\text{m}^2 \cdot 24 \text{ h}$) and a pressure-sensitive adhesive layer (thickness: 10 μm) formed on the PET-based film.

Further, a separator (thickness: 38 μm , moisture permeability: 18 $\text{g}/\text{m}^2 \cdot 24 \text{ h}$) was bonded to the liquid crystal alignment fixed layer B (Q layer) side of the laminate precursor via a pressure-sensitive adhesive layer (thickness: 15 μm). Thus, a laminate having a sheet shape and measuring 165 mm by 80 mm was obtained.

A total of 500 laminates each having a sheet shape and measuring 165 mm by 80 mm were produced in the same manner.

[0080] (Humidifying Treatment)

The resultant 500 laminates each having a sheet shape were superimposed on each other to provide a laminate assembly, and as illustrated in FIG. 5, the laminates were subjected to humidifying treatment under a state in which each of the laminates was placed on a placement surface so that the main surface of the laminate formed an angle of 90° with respect to the placement surface. Specifically, the 500 laminates (laminate assembly) were housed in a case having a predetermined size, and the laminates were subjected to humidifying treatment under a state in which each of the laminates was placed on an inner bottom surface of the case (placement surface) so that the main surface of the laminate formed an angle of 90° with respect to the placement surface. Herein, the humidifying treatment was performed under a state in which the long side of each of the laminates was brought into contact with the inner bottom surface of the case, and a vacant space in the case (a space between the main surface of each of the laminates positioned at a front end and a back end of the laminate assembly and an inner side surface of the case) was filled with an unfoamed polystyrene (PS) sheet. The humidifying treatment was performed at 23°C and 60%RH (a water vapor amount of 12.4 g/m^3) for 24 hours.

Thus, a polarizing plate with a retardation layer was obtained.

[0081] [Example 2]

A polarizing plate with a retardation layer was obtained in the same manner as in Example 1 except that a TAC film (thickness: 27 μm) was used instead of using the HC-COP film as the protective layer in the production of the polarizing plate.

[0082] [Comparative Example 1]

A polarizing plate with a retardation layer was obtained in the same manner as in Example 1 except that the laminate precursor having an elongate shape was not cut, and the laminate having an elongate shape was produced and subjected to the humidifying treatment under a state of being wound in a roll shape.

[0083] [Comparative Example 2]

A polarizing plate with a retardation layer was obtained in the same manner as in Example 1 except that, in the humidifying treatment, the laminate assembly was placed on the placement surface so that the main surface of each of the laminates formed an angle of 0° with respect to the placement surface (the 500 laminates were placed on the placement surface so as to be superimposed on each other).

[0084] [Comparative Example 3]

A polarizing plate with a retardation layer was obtained in the same manner as in Example 1 except that the humidifying treatment was performed at 23°C and 45%RH (a water vapor amount of 9.3 g/m³) for 24 hours.

[0085] [Reference Example 1]

An elongate roll of a PVA-based resin film having a thickness of 60 μm was uniaxially stretched in its lengthwise 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 22 μm. A TAC film with a HC layer (thickness: 71 μm) was bonded to one surface of the resultant polarizer. Further, a polycarbonate resin retardation film (thickness: 58 μm) that showed a reverse wavelength dispersion characteristic and had an Re(550) of 140 nm was bonded to the other surface of the polarizer. Herein, the bonding was performed so that the slow axis of the retardation film and the absorption axis of the polarizer formed an angle of 45°. Thus, a polarizing plate with a retardation layer was obtained. The polarizing plate with a retardation layer had a total thickness of 151 μm and a thickness ratio of 1.6. The polarizing plate with a retardation layer was cut out into a size measuring 165

mm by 80 mm, and was left at rest on a flat surface. As a result, no warping was observed.

[0086] [Reference Example 2]

A polarizer having a thickness of 22 μm was produced in the same manner as in Reference Example 1. A TAC film with a HC layer (thickness: 91 μm) was bonded to one surface of the resultant polarizer, and a TAC film (thickness: 80 μm) was bonded to the other surface thereof to provide a polarizing plate. A polarizing plate with a retardation layer having the configuration "TAC film with a HC layer/polarizer/TAC film/adhesive layer/retardation layer (H layer)/adhesive layer/retardation layer (Q layer)" was obtained in the same manner as in Example 1 except that the polarizing plate was used. The polarizing plate with a retardation layer had a total thickness of 197 μm and a thickness ratio of 48. The polarizing plate with a retardation layer was cut out into a size measuring 165 mm by 80 mm, and was left at rest on a flat surface. As a result, no warping was observed.

[0087] The polarizing plates with retardation layers of Examples and Comparative Examples were subjected to the following evaluations. The evaluation results are summarized in Tables 1 and 2.

<Evaluation>

1. Change in Weight per Unit Area

The weight of a laminated portion from the polarizing plate to the pressure-sensitive adhesive layer (the laminated portion **80** illustrated in FIG. **4**) was measured before and after the humidification with an electronic balance. A change in weight thereof per unit area was calculated from the resultant measurement values.

2. Warping Amount

The laminate precursor having a sheet shape and the polarizing plate with a retardation layer were each left at rest on a flat surface so that the retardation layer side thereof was on a flat surface side. At this time, a warping amount was determined by measuring the height of the highest portion from the flat surface.

A case in which warping is convex on a rest placement surface side is represented as "Positive (+)", and a case in which warping is convex on a side opposite to the rest placement surface side is represented as "Negative (-)". In addition, the "(MD)" in the tables corresponds to the conveyance direction of the roll conveyance, and corresponds to the absorption axis direction of the polarizer.

3. External Appearance

The external appearance of the resultant polarizing plate with a retardation layer was visually observed. The evaluation criteria are as described below.

(Evaluation Criteria)

Good: No indentation is observed.

Poor: An indentation is observed.

[0088]

Table 1

	Laminate precursor				
	Total thickness (μm)	Thickness ratio	Temperature/humidity at the time of lamination (°C/%RH)	Water vapor amount A1 (g/m ³)	Warping amount (mm)
Example 1	36	8	23/45	9.3	-40 (MD)
Example 2	36	8	23/45	9.3	-40 (MD)
Comparative Example 1	36	8	23/45	9.3	-40 (MD)
Comparative Example 2	36	8	23/45	9.3	-40 (MD)
Comparative Example 3	36	8	23/45	9.3	-40 (MD)

[0089]

Table 2

	Humidifying treatment					Change in weight per unit area (%)	Warping amount (mm)	External appearance
	State of laminate	Temperature/humidity (°C/%RH)	Water vapor amount A2 (g/m ³)	A2-A1 (g/m ³)	Time (hours)			
Example 1	Horizontal	23/60	12.4	3.1	24	+0.1 to 0.4	-20 (MD) to +20 (TD)	Good
Example 2	Horizontal	23/60	12.4	3.1	24	+0.1 to 0.4	-20 (MD) to +20 (TD)	Good
Comparative Example 1	Roll shape	23/60	12.4	3.1	24	0	-40 (MD)	Good
Comparative Example 2	Vertical	23/60	12.4	3.1	24	+0.1 to 0.7	-20 (MD) to +40 (TD)	Poor
Comparative Example 3	Horizontal	23/45	9.3	0	24	0	-40 (MD)	Good

[0090] As apparent from Tables 1 and 2, in each of Examples 1 and 2, it can be recognized that the change in weight through the humidifying treatment fell within the range of from 0.1% to 0.4%, and the warping of the resultant polarizing plate with a

retardation layer fell within the range of from -20 mm to +20 mm (warping in a MD direction was observed in the case represented by Symbol "-", and warping in a TD direction perpendicular to the MD direction was observed in the case represented by Symbol "+"). As described above, in each of Examples 1 and 2, moisture was able to be uniformly imparted to the plurality of laminates, and also the degree of correction of the warping having occurred in the laminate precursor was highly uniform.

In contrast, in Comparative Example 2, in which the laminates were superimposed on each other and placed on the placement surface, variations in the change in weight through the humidifying treatment were recognized. Specifically, upper laminates of the laminate assembly were subjected to lower force than lower laminates thereof, and the upper laminates absorbed a larger amount of moisture than the lower laminates. In each of the upper laminates, warping that was convex in a reverse direction with respect to warping having occurred in the laminate precursor was observed. Meanwhile, warping having occurred in the laminate precursor was improved in each of the lower laminates. As described above, variations in the degree of correction of the warping having occurred in the laminate precursor were recognized. In addition, an indentation was observed in the resultant polarizing plate with a retardation layer.

[0091] In Comparative Example 1, in which the laminate was subjected to the humidifying treatment under a state of being wound in a roll shape, the weight per unit area was not changed in an inner portion of the laminate wound in a roll shape, and the warping was not improved.

As apparent from Reference Example, it can be said that such warping is a problem peculiar to a polarizing plate with a retardation layer having a small total thickness and a large ratio of the thickness of the polarizing plate to the total thickness.

Industrial Applicability

[0092] The polarizing plate with a retardation layer according to one embodiment of the present invention is used as a polarizing plate with a retardation layer of an image display apparatus, and may be suitably used particularly in an image display apparatus that is curved, or is bendable, foldable, or windable. Examples of the image display apparatus typically include a liquid crystal display apparatus, an organic EL display apparatus, and an inorganic EL display apparatus.

Reference Signs List

[0093] **10** polarizing plate

11 polarizer
12 protective layer
20 retardation layer
21 first retardation layer (H layer)
22 second retardation layer (Q layer)
31 first protective film
32 second protective film
90 laminate precursor
100 laminate

Claims

[Claim 1] A method of producing a polarizing plate with a retardation layer, comprising:

preparing a laminate including a first protective film, a polarizing plate including a polarizer and a protective layer arranged on at least one side of the polarizer, a retardation layer, and a second protective film in the stated order, having a total of a thickness of the polarizing plate and a thickness of the retardation layer of 50 μm or less, and having a ratio of the thickness of the polarizing plate to the thickness of the retardation layer of 5 or more; and

placing the laminate under an environment having a water vapor amount of 10.5 g/m³ or more under a state in which the laminate is placed on a placement surface, to thereby subject the laminate to humidifying treatment,

wherein the placing is performed under a state in which a main surface of the laminate has an angle with respect to the placement surface.

[Claim 2] The production method according to claim 1, comprising laminating the polarizing plate and the retardation layer to obtain a laminate precursor.

[Claim 3] The production method according to claim 2, comprising cutting the laminate precursor into a sheet shape.

[Claim 4] The production method according to any one of claims 1 to 3, wherein the humidifying treatment is performed under a state in which a plurality of the laminates are arranged next to each other.

[Claim 5] The production method according to any one of claims 1 to 4, wherein the first protective film has a moisture permeability at 40°C and 92%RH of 30 g/m²·24 h or less.

[Claim 6] The production method according to any one of claims 1 to 5, wherein the second protective film has a moisture permeability at 40°C and 92%RH of 30 g/m²·24 h or less.

[Claim 7] The production method according to any one of claims 1 to 6, comprising laminating the polarizing plate and the retardation layer while roll conveying the polarizing plate and the retardation layer.

[Claim 8] The production method according to any one of claims 1 to 7, comprising laminating the polarizing plate and the retardation layer with an active energy ray-curable adhesive.

[Claim 9] The production method according to claim 8, wherein the active energy ray-curable adhesive has a thickness after

curing of 0.4 μm or more.

[Claim 10] The production method according to any one of claims 1 to 9,

wherein the laminate includes a pressure-sensitive adhesive layer arranged on a side of the retardation layer on which the polarizing plate is prevented from being arranged, and

wherein a laminated portion of the polarizing plate, the retardation layer, and the pressure-sensitive adhesive layer has an increase in weight per unit area of 0.1% or more through the humidifying treatment.

[Claim 11] The production method according to any one of claims 1 to 10, wherein a period of time of the humidifying treatment is 6 hours or more.

[Claim 12] The production method according to any one of claims 1 to 11, wherein the water vapor amount at a time of the humidifying treatment is from 10.5 g/m^3 to 30 g/m^3 .

[Claim 13] The production method according to any one of claims 1 to 12, comprising laminating the polarizing plate and the retardation layer under an environment having a water vapor amount of 10.2 g/m^3 or less.

[Claim 14] The production method according to any one of claims 1 to 13, wherein the water vapor amount at a time of the humidifying treatment is higher than a water vapor amount at a time of laminating the polarizing plate and the retardation layer by 0.5 g/m³ or more.

[Claim 15] The production method according to any one of claims 1 to 14, wherein the retardation layer or the protective layer has a moisture permeability at 40°C and 92%RH of 300 g/m²·24 h or more.

[Claim 16] The production method according to any one of claims 1 to 15, wherein the polarizing plate has the protective layer arranged only on a side of the polarizer on which the retardation layer is prevented from being arranged.

[Claim 17] The production method according to any one of claims 1 to 16, wherein a center of gravity of the polarizer in a thickness direction is positioned on a retardation layer side with respect to a center of gravity of a laminated portion of the polarizing plate and the retardation layer in a thickness direction.

[Claim 18] The production method according to any one of claims 1 to 17, wherein the retardation layer is an alignment fixed

layer of a liquid crystal compound.