

Description

Title of Invention: POLARIZING PLATE WITH RETARDATION LAYER AND
IMAGE DISPLAY DEVICE USING SAME

Technical Field

[0001] The present invention relates to a polarizing plate with a retardation layer and an image display apparatus using the same.

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 and the retardation plate 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. To cope with such demand, as a retardation layer, there has been proposed a layer formed by aligning a liquid crystal compound in a predetermined

direction and fixing the alignment state. However, the layer formed from such liquid crystal compound involves a problem in that the layer is liable to peel.

Citation List

Patent Literature

[0003] [PTL 1] JP 5745686 B2

Summary of Invention

Technical Problem

[0004] The present invention has been made to solve the conventional problem, and a primary object of the present invention is to provide a polarizing plate with a retardation layer, which includes an alignment fixed layer of a liquid crystal compound and in which the peeling of the alignment fixed layer of the liquid crystal compound is suppressed.

Solution to Problem

[0005] A polarizing plate with a retardation layer according to an embodiment of the present invention includes: a polarizing plate including a polarizer and a protective layer arranged on at least one side of the polarizer; a first adhesive layer; and a retardation layer laminated on the polarizing plate via the first adhesive layer. The retardation layer is an alignment fixed layer of a liquid crystal compound, and includes

a permeation layer, which is formed by permeation of an adhesive of the first adhesive layer into a vicinity of an interface thereof with the first adhesive layer.

In one embodiment of the present invention, the polarizing plate includes the polarizer and the protective layer arranged on a side of the polarizer opposite to the retardation layer.

In one embodiment of the present invention, the polarizing plate includes the polarizer and the protective layers arranged on both sides of the polarizer.

In one embodiment of the present invention, the protective layer arranged on a retardation layer side of the polarizer includes a permeation layer, which is formed by permeation of the adhesive of the first adhesive layer into a vicinity of an interface thereof with the first adhesive layer.

In one embodiment of the present invention, the retardation layer is a single layer of the alignment fixed layer of the liquid crystal compound. The retardation layer has an $\text{Re}(550)$ of from 100 nm to 190 nm, and a slow axis of the retardation layer and an absorption axis of the polarizer form an angle of from 40° to 50° .

In one embodiment of the present invention, the retardation layer includes a first alignment fixed layer of a liquid crystal compound, and a second alignment fixed layer of a liquid crystal compound laminated on the first alignment fixed layer of the liquid crystal compound via a second adhesive layer. The first alignment fixed layer of the liquid crystal compound and the second alignment fixed layer of the liquid crystal compound each include a permeation layer, which is formed by permeation of an adhesive of the second adhesive layer into a vicinity of an interface thereof with the second adhesive layer. The first alignment fixed layer of the liquid crystal compound 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 alignment fixed layer of the liquid crystal compound 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° .

In one embodiment of the present invention, the adhesives of the first adhesive layer and the second adhesive layer each contain acryloylmorpholine.

In one embodiment of the present invention, the polarizing plate with a retardation layer further includes another retardation layer outside the retardation layer, wherein a

refractive index characteristic of the another retardation layer shows a relationship of $n_z > n_x = n_y$.

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

Advantageous Effects of Invention

[0006] According to the present invention, in the polarizing plate with a retardation layer including the alignment fixed layer of the liquid crystal compound, the permeation layer is arranged, which is formed by the permeation of the adhesive of the adjacent adhesive layer into the vicinity of the interface in the alignment fixed layer of the liquid crystal compound with the adhesive layer,. Accordingly, the polarizing plate with a retardation layer in which the peeling of the alignment fixed layer of the liquid crystal compound is suppressed can be achieved.

Brief Description of Drawings

[0007] FIG. 1 is a schematic sectional view of a polarizing plate with a retardation layer according to one embodiment of the present invention.

FIG. 2 is a schematic sectional view of a polarizing plate with a retardation layer according to another embodiment of the present invention.

FIG. 3 is a schematic sectional view of a polarizing plate with a retardation layer according to still another embodiment of the present invention.

FIG. 4 is a transmission electron microscope (TEM) image for showing the state of an interface between an adhesive layer and a retardation layer in the polarizing plate with a retardation layer of Example 1.

FIG. 5 is a TEM image for showing the state of an interface between an adhesive layer and a retardation layer in the polarizing plate with a retardation layer of Comparative Example 1.

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 (R_e)

" $R_e(\lambda)$ " refers to an in-plane retardation measured at 23°C with light having a wavelength of λ nm. For example, " $R_e(550)$ " refers to an in-plane retardation measured at 23°C with light having a wavelength of 550 nm. The $R_e(\lambda)$ is determined from the equation " $R_e(\lambda) = (n_x - n_y) \times d$ " 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) Nz Coefficient

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

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

(6) Alignment Fixed Layer

The term "alignment fixed layer" refers to a layer in which a liquid crystal compound is aligned in a predetermined direction 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.

(7) (Meth)acryl

The term "(meth)acryl" refers to acryl and/or methacryl.

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

FIG. 1 is a schematic sectional view of a polarizing plate with a retardation layer according to one embodiment of the

present invention. A polarizing plate **100** with a retardation layer of the illustrated example includes a polarizing plate **10** and a retardation layer **20** laminated on the polarizing plate **10** via a first adhesive layer **31**. The polarizing plate typically includes a polarizer and a protective layer arranged on at least one side of the polarizer. The polarizing plate **10** of the illustrated example includes a polarizer **11** and a first protective layer **12** arranged on one side (side opposite to the retardation layer) of the polarizer **11**. In the embodiment of the present invention, the retardation layer **20** is an alignment fixed layer of a liquid crystal compound, and includes a permeation layer **20a**, which is formed by the permeation of the adhesive of the first adhesive layer **31** into the vicinity of its interface with the first adhesive layer **31**. The arrangement of such permeation layer can significantly suppress the peeling of the retardation layer (the alignment fixed layer of the liquid crystal compound). Further, when the first adhesive layer **31** is directly arranged on the polarizer **11** like this embodiment, the peeling of the retardation layer (the alignment fixed layer of the liquid crystal compound) can be particularly significantly suppressed. According to the configuration of this embodiment, for example, a peel strength between the first adhesive layer and the alignment fixed layer of the liquid crystal compound becomes so large that the first adhesive layer and the alignment fixed layer of the liquid crystal compound are not peeled from

each other by a normal peeling operation, and any other interlayer peeling (delamination) (e.g., peeling between the polarizer and the first adhesive layer) can be prevented.

[0011] FIG. 2 is a schematic sectional view of a polarizing plate with a retardation layer according to another embodiment of the present invention. In a polarizing plate **101** with a retardation layer of the illustrated example, the polarizing plate **10** includes the polarizer **11**, the first protective layer **12** arranged on one side (side opposite to the retardation layer) of the polarizer **11**, and a second protective layer **13** arranged on the other side (retardation layer side) of the polarizer **11**. In this embodiment, the second protective layer **13** may include a permeation layer **13a**, which is formed by the permeation of the adhesive of the first adhesive layer **31** into the vicinity of its interface with the first adhesive layer **31**. When the permeation layer **13a** is arranged, for example, peeling between the first adhesive layer and the alignment fixed layer of the liquid crystal compound can be prevented, and a peel strength between the first adhesive layer and the second protective layer can be improved. The permeation layer **13a** is optional, and may be formed in the second protective layer **13**, or may not be formed therein.

[0012] As described above, the retardation layer **20** is the

alignment fixed layer of the liquid crystal compound. The retardation layer **20** may be such a single layer of the alignment fixed layer as illustrated in FIG. **1** and FIG. **2**, or may have such a laminated structure of a first alignment fixed layer **21** and a second alignment fixed layer **22** as illustrated in FIG. **3**. In an embodiment illustrated in FIG. **3**, the first alignment fixed layer **21** and the second alignment fixed layer **22** are laminated via a second adhesive layer **32**. In this case, the first alignment fixed layer **21** includes a permeation layer **21a**, which is formed by the permeation of the adhesive of the second adhesive layer **32** into the vicinity of its interface with the second adhesive layer **32**, and the second alignment fixed layer **22** includes a permeation layer **22a**, which is formed by the permeation of the adhesive of the second adhesive layer **32** into the vicinity of its interface with the second adhesive layer **32**. In this embodiment, peeling between the second adhesive layer, and each of the first alignment fixed layer **21** and the second alignment fixed layer **22** can be particularly significantly suppressed. For example, the second adhesive layer, and each of the first alignment fixed layer **21** and the second alignment fixed layer **22** are not peeled from each other by a normal peeling operation, and the cohesive failure of the second adhesive layer may occur. In the embodiment of the present invention, the permeation layer **20a** (**21a** in this embodiment), which is formed by the permeation of the adhesive of the first adhesive layer **31**

into the vicinity of the interface of the retardation layer **20** with the first adhesive layer **31**, only needs to be formed. Accordingly, the first alignment fixed layer **21** and the second alignment fixed layer **22** may be laminated via, for example, a pressure-sensitive adhesive layer.

[0013] As described above, the permeation layers are formed by the permeation of the adhesives of the adhesive layers. Specifically, the permeation layers **20a**, **21a**, and **22a** are portions in the alignment fixed layers **20**, **21**, and **22** of the liquid crystal compounds where an adhesive component is present, respectively, and the permeation layer **13a** is a portion in the second protective layer **13** where the adhesive component is present. Although detailed structures of the permeation layers are unclear, it is assumed that the entanglement of a molecule of the permeated adhesive (substantially, its curable component before curing) and a liquid crystal molecule of any one of the alignment fixed layers or a resin molecule for forming the second protective layer (in some cases, a chemical bond by a reaction therebetween) is formed to suppress peeling between the alignment fixed layer or the protective layer and the corresponding adhesive layer. Further, the formation of any such permeation layer suppresses interface reflection, and as a result, can suppress display unevenness.

[0014] The thickness of each of the permeation layers is preferably from 5 nm to 100 nm, more preferably from 10 nm to 50 nm. The ratio (permeation layer/alignment fixed layer) of the thickness of each of the permeation layers to the thickness of the corresponding alignment fixed layer of the liquid crystal compound is preferably from 0.2% to 20%, more preferably from 0.2% to 10%. When the thickness of each of the permeation layers and the ratio of the thickness fall within such ranges, peeling between any one of the alignment fixed layers and the corresponding adhesive layer can be satisfactorily suppressed, and the display unevenness can be satisfactorily suppressed. When the thickness of each of the permeation layers becomes excessively large, the permeation layer and/or the corresponding adhesive layer becomes brittle, and hence the peeling is liable to occur instead in some cases. The thickness of each of the permeation layers may be measured from a transmission electron microscope (TEM) image of a section of the polarizing plate with a retardation layer.

[0015] A peel strength between the first adhesive layer **31** and the alignment fixed layer **20** of the liquid crystal compound is preferably 0.7 N/15 mm or more, more preferably 1.0 N/15 mm or more, still more preferably 1.5 N/15 mm or more. The upper limit of the peel strength is hard to specify. This is because the cohesive failure of the first adhesive layer or interlayer

peeling between the first adhesive layer and the polarizing plate (typically, the second protective layer) occurs before the first adhesive layer **31** and the alignment fixed layer **20** of the liquid crystal compound peel from each other. The same holds true for a peeling strength between the second adhesive layer **32**, and each of the first alignment fixed layer **21** and the second alignment fixed layer **22**. The peeling strengths may each be measured at, for example, a peel angle of 90° and a peel rate of 300 mm/min.

[0016] The above-mentioned embodiments may be appropriately combined, or modifications obvious in the art may be made to constituent elements in the above-mentioned embodiments. For example, such second protective layer as illustrated in FIG. **2** may be arranged on the polarizing plate of the polarizing plate with a retardation layer of FIG. **3**, the retardation layer of the polarizing plate with a retardation layer of FIG. **2** may have such a laminated structure of the first alignment fixed layer **21** and the second alignment fixed layer **22** as illustrated in FIG. **3**, and the retardation layers of the polarizing plates with retardation layers of FIG. **1** to FIG. **3** may each be replaced with an optically equivalent configuration as long as the configuration is an alignment fixed layer of a liquid crystal compound.

[0017] The polarizing plate with a retardation layer according to the embodiment of the present invention may further include any other optical functional layer. For example, the polarizing plate with a retardation layer may further include another retardation layer and/or a conductive layer or an isotropic substrate with a conductive layer (none of the layers is shown). The other retardation layer and the conductive layer or the isotropic substrate with a conductive layer are typically arranged outside the retardation layer **20** (side opposite to the polarizing plate **10**). The refractive index characteristic of the other retardation layer typically shows a relationship of $n_z > n_x = n_y$. Such other retardation layer may be arranged in, for example, the case where the retardation layer **20** is a single layer of the alignment fixed layer. The other retardation layer and the conductive layer or the isotropic substrate with a conductive layer are typically arranged in the stated order from the retardation layer **20** side. The other retardation layer and the conductive layer or the isotropic substrate with a conductive layer are typically optional layers to be arranged as required, and one or both of the layers may be omitted. When the conductive layer or the isotropic substrate with a conductive layer is arranged, the polarizing plate with a retardation layer 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. The kinds, characteristics, number, combination, arrangement positions, and the like of the optical functional layers that may be arranged in the polarizing plate with a retardation layer may be appropriately set in accordance with purposes.

[0018] The polarizing plate with a retardation layer of the present invention 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 a retardation layer of an elongate shape can be typically wound in a roll shape.

[0019] In practical use, a pressure-sensitive adhesive layer (not shown) is arranged as an outermost layer on the side of the retardation layer opposite to the polarizing plate, and hence the polarizing plate with a retardation layer can be bonded to an image display cell. Further, it is preferred that a release film be temporarily bonded to the surface of the pressure-sensitive adhesive layer until the polarizing plate with a retardation layer is used. The temporary bonding of the release film protects the pressure-sensitive adhesive layer and enables the formation of a roll of the polarizing plate with a

retardation layer.

[0020] The total thickness of the polarizing plate with a retardation layer is preferably 100 μm or less, more preferably 80 μm or less, still more preferably 60 μm or less, particularly preferably 55 μm or less. The lower limit of the total thickness may be, for example, 28 μm . According to the embodiment of the present invention, such an extremely thin polarizing plate with a retardation layer can be achieved. Such polarizing plate with a retardation layer may have extremely excellent flexibility and extremely excellent bending durability. Such polarizing plate with a retardation layer may be particularly suitably applied to a curved image display apparatus and/or a bendable or foldable image display apparatus. The total thickness of the polarizing plate with a retardation layer refers to the total of the thicknesses of all layers for forming the polarizing plate with a retardation layer except the pressure-sensitive adhesive layer.

[0021] The constituent elements of the polarizing plate with a retardation layer are described in more detail below.

[0022] 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.

[0023] 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.

[0024] 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.

[0025] 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. The entire description of the laid-open publication is incorporated herein by reference.

[0026] 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 range, curling at the time of heating can be satisfactorily suppressed, and satisfactory appearance durability at the time of heating is obtained.

[0027] 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 from 43.0% to 46.0%, 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.

[0028] B-2. Protective Layer

The first protective layer **12** and the second protective layer **13** 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.

[0029] As described later, the polarizing plate with a retardation layer according to the embodiment of the present invention is typically arranged on the viewer side of an image display apparatus, and the first protective layer **12** is typically arranged on its viewer side. Accordingly, the first 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 first 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 a retardation layer is suitably applicable even to an image display apparatus that may be used outdoors.

[0030] The thickness of the first protective layer is typically 300 μm or less, preferably 100 μm or less, more preferably from 5 μm to 80 μm , still more preferably from 10 μm to 60 μm . When the first protective layer is subjected to surface treatment, its thickness is a thickness including the thickness of the surface-treated layer.

[0031] In one embodiment, it is preferred that the second protective layer **13** 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. In one embodiment, the second protective layer **13** may be a retardation layer having any appropriate retardation value. In this case, the in-plane retardation $\text{Re}(550)$ of the retardation layer may be, for example, from 110 nm to 150 nm. The thickness of the second protective layer is preferably from 5 μm to 200 μm , more preferably from 10 μm to 100 μm , still more preferably from 10 μm to 60 μm .

[0032] C. Retardation Layer

As described above, the retardation layer **20** is an alignment fixed layer of a liquid crystal compound. When the liquid crystal compound is used, the difference between n_x and n_y of the retardation layer to be obtained can be markedly

increased as compared to a non-liquid crystal material, and hence the thickness of the retardation layer required for obtaining a desired in-plane retardation can be markedly reduced. As a result, further thinning of the polarizing plate with a retardation layer can be achieved. In this embodiment, a rod-shaped liquid crystal compound is typically aligned in a state of being aligned in the slow axis direction of the retardation layer (homogeneous alignment).

[0033] 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.

[0034] 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.

[0035] 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.

[0036] 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.

[0037] The alignment fixed layer of a liquid crystal compound 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 alignment fixed layer formed on the substrate may be transferred onto the surface of the polarizing plate **10**. In another embodiment, the substrate may be a second protective layer **13**. In this case, the transfer step is eliminated, lamination can be performed by a roll-to-roll process continuously from the formation of the alignment fixed layer (retardation layer), and hence productivity is further improved.

[0038] 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.

[0039] 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.

[0040] 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.

[0041] Specific examples of the liquid crystal compound and details of the method of forming the alignment fixed layer are described in, for example, JP 2006-163343 A, the description of which is incorporated herein by reference.

[0042] In one embodiment, the retardation layer **20** is a single layer of the alignment fixed layer of the liquid crystal compound as illustrated in FIG. **1** and FIG. **2**. When the retardation layer **20** includes a single layer of the alignment fixed layer of the liquid crystal compound, its thickness is preferably from 0.5 μm to 7 μm , more preferably from 1 μm to 5 μm . When the liquid crystal compound is used, an in-plane retardation comparable to that of a resin film can be achieved by a thickness much smaller than that of the resin film.

[0043] The refractive index characteristic of the retardation layer typically shows a relationship of $n_x > n_y = n_z$. The retardation layer is typically arranged for imparting an antireflection characteristic to the polarizing plate, and in the case where the retardation layer is a single layer of the alignment fixed layer, the layer can function as a $\lambda/4$ plate.

In this case, the in-plane retardation $R_e(550)$ of the retardation layer is preferably from 100 nm to 190 nm, more preferably from 110 nm to 170 nm, still more preferably from 130 nm to 160 nm. Herein, 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.

[0044] The N_z 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 a retardation layer to be obtained is used in an image display apparatus, an extremely excellent reflection hue can be achieved.

[0045] 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. In one embodiment, the retardation layer shows a reverse wavelength dispersion characteristic. In this case, the ratio "Re(450)/Re(550)" of the retardation layer is preferably 0.8 or more and less than 1, more preferably 0.8 or more and 0.95 or less. With such configuration, an extremely excellent antireflection characteristic can be achieved.

[0046] An angle θ formed by the slow axis of the retardation layer **20** and the absorption axis of the polarizer **11** is preferably from 40° to 50° , more preferably from 42° to 48° , still more preferably about 45° . When the angle θ falls within such ranges, through use of the retardation layer as a $\lambda/4$ plate as described above, a polarizing plate with a retardation layer having an extremely excellent circular polarization characteristic (consequently, an extremely excellent antireflection characteristic) can be obtained.

[0047] In another embodiment, the retardation layer **20** may have a laminated structure of the first alignment fixed layer **21** and the second alignment fixed layer **22** as illustrated in FIG. **3**. In this case, one of the first alignment fixed layer **21** and the second alignment fixed layer **22** may function as a $\lambda/4$ plate, and the other may function as a $\lambda/2$ plate. Accordingly, the thickness of each of the first alignment fixed layer **21** and the second alignment fixed layer **22** may be adjusted so that a desired

in-plane retardation of a $\lambda/4$ plate or a $\lambda/2$ plate may be obtained. For example, when the first alignment fixed layer **21** functions as a $\lambda/2$ plate, and the second alignment fixed layer **22** functions as a $\lambda/4$ plate, the thickness of the first alignment fixed layer **21** is, for example, from 2.0 μm to 3.0 μm , and the thickness of the second alignment fixed layer **22** is, for example, from 1.0 μm to 2.0 μm . In this case, the in-plane retardation $\text{Re}(550)$ of the first alignment fixed layer is preferably from 200 nm to 300 nm, 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 alignment fixed layer is as described above for the single-layer alignment fixed layer. An angle formed by the slow axis of the first alignment fixed layer and the absorption axis of the polarizer is preferably from 10° to 20° , more preferably from 12° to 18° , still more preferably about 15° . An angle formed by the slow axis of the second alignment fixed layer and the absorption axis of the polarizer is preferably from 70° to 80° , 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. Liquid crystal compounds for forming the first alignment fixed layer and the second alignment fixed layer, methods of forming the first alignment fixed layer and the second alignment fixed layer, their

optical characteristics, and the like are as described above for the single-layer alignment fixed layer.

[0048] D. Adhesive Layers

The first adhesive layer and the second adhesive layer 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 that can permeate an alignment fixed layer of a liquid crystal compound to form a permeation layer 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.

[0049] 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.

[0050] 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).

[0051] 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 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 heptadecafluorodecyl (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.

[0052] 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.

[0053] 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 is applied so that such thickness may be obtained, a permeation layer having an appropriate thickness can be formed.

[0054] Details of the adhesive are described in, for example, JP 2018-017996 A, the description of which is incorporated herein by reference.

[0055] E. Other Retardation Layer

As described above, the other retardation layer may be a so-called positive C-plate whose refractive index characteristic shows a relationship of $n_z > n_x = n_y$. In the case where the positive C-plate is used as the other retardation layer, reflection in an oblique direction can be satisfactorily prevented, and hence the viewing angle of the antireflection function of the polarizing plate with a retardation layer can be widened. In this case, the thickness direction retardation $R_{th}(550)$ of the other

retardation layer is preferably from -50 nm to -300 nm, more preferably from -70 nm to -250 nm, still more preferably from -90 nm to -200 nm, particularly preferably from -100 nm to -180 nm. Herein, " $n_x=n_y$ " encompasses not only a case in which n_x and n_y are strictly equal to each other but also a case in which n_x and n_y are substantially equal to each other. That is, the in-plane retardation $R_e(550)$ of the other retardation layer may be less than 10 nm.

[0056] The other retardation layer having a refractive index characteristic of $n_z > n_x = n_y$ may be formed of any appropriate material. The other retardation layer is preferably formed of a film containing a liquid crystal material fixed in homeotropic alignment. The liquid crystal material (liquid crystal compound) that can be homeotropically aligned may be a liquid crystal monomer, or may be a liquid crystal polymer. The liquid crystal compound and a method of forming the retardation layer are specifically, for example, a liquid crystal compound and a method of forming the retardation layer described in paragraphs [0020] to [0028] of JP 2002-333642 A. In this case, the thickness of the other retardation layer is preferably from 0.5 μm to 10 μm , more preferably from 0.5 μm to 8 μm , still more preferably from 0.5 μm to 5 μm .

[0057] F. Conductive Layer or Isotropic Substrate with

Conductive Layer

The conductive layer may be formed by forming a metal oxide film on any appropriate substrate through any appropriate film forming method (e.g., a vacuum vapor deposition method, a sputtering method, a CVD method, an ion plating method, and a spraying method). Examples of the metal oxide include indium oxide, tin oxide, zinc oxide, indium-tin composite oxide, tin-antimony composite oxide, zinc-aluminum composite oxide, and indium-zinc composite oxide. Of those, an indium-tin composite oxide (ITO) is preferred.

[0058] When the conductive layer contains the metal oxide, the thickness of the conductive layer is preferably 50 nm or less, more preferably 35 nm or less. The lower limit of the thickness of the conductive layer is preferably 10 nm.

[0059] The conductive layer may be transferred from the substrate onto the retardation layer (or, if present, the other retardation layer) so that the conductive layer alone may serve as a layer forming the polarizing plate with a retardation layer, or the conductive layer may be laminated as a laminate of the conductive layer and the substrate (substrate with a conductive layer) on the retardation layer (or, if present, the other retardation layer). It is preferred that the substrate be optically isotropic. Accordingly, the conductive layer may be

used as an isotropic substrate with a conductive layer in the polarizing plate with a retardation layer.

[0060] As the substrate that is optically isotropic (isotropic substrate), any appropriate isotropic substrate may be adopted. Examples of a material forming the isotropic substrate include: a material containing, as its main skeleton, a resin having no conjugated system, such as a norbornene-based resin or an olefin-based resin; and a material having, in the main chain of an acrylic resin, a cyclic structure, such as a lactone ring or a glutarimide ring. When any such material is used, at the time of the formation of the isotropic substrate, the expression of a retardation along with the orientation of the molecular chain of the material can be suppressed to a low level. The thickness of the isotropic substrate is preferably 50 μm or less, more preferably 35 μm or less. The lower limit of the thickness of the isotropic substrate is, for example, 20 μm .

[0061] The conductive layer and/or the conductive layer of the isotropic substrate with a conductive layer may be patterned as required. Through the patterning, a conductive part and an insulating part may be formed. As a result, an electrode may be formed. The electrode may function as a touch sensor electrode configured to sense contact with a touch panel. Any appropriate

method may be adopted as a method for the patterning. Specific examples of the patterning method include a wet etching method and a screen printing method.

[0062] G. Image Display Apparatus

The polarizing plate with a retardation layer described in the section A to the section F may be applied to an image display apparatus. Accordingly, the present invention encompasses an image display apparatus using such polarizing plate with a retardation 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 (e.g., a quantum dot display apparatus)). An image display apparatus according to an embodiment of the present invention includes, on its viewer side, the polarizing plate with a retardation layer described in the section A to the section F. The polarizing plate with a retardation layer is laminated so that the retardation layer may be arranged on an image display cell (e.g., liquid crystal cell, organic EL cell, or inorganic EL cell) side (so that the polarizer may be arranged on the viewer side). 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 polarizing plate with a retardation layer of the present

invention becomes significant.

Examples

[0063] 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.

[0064] [Production Example 1]

50 Parts of an unsaturated fatty acid hydroxyalkyl ester-modified ϵ -caprolactone ("PLACCEL FA1DDM" manufactured by Daicel Corporation), 40 parts of acryloylmorpholine ("ACMO (trademark)" manufactured by Kohjin Co., Ltd.), and 10 parts of an acrylic oligomer ("ARFON UP-1190" manufactured by Toagosei Co., Ltd.), and 3 parts of "KAYACURE DETX-S" (manufactured by Nippon Kayaku Co., Ltd.) and 3 parts of OMNIRAD 907 (manufactured by IGM Resins Italia S.r.l.) serving as photopolymerization initiators were mixed to prepare an adhesive A.

[0065] [Production Example 2]

50 Parts of an unsaturated fatty acid hydroxyalkyl ester-modified ϵ -caprolactone ("PLACCEL FA1DDM" manufactured by Daicel Corporation), 40 parts of phenoxydiethylene glycol acrylate

("LIGHT ACRYLATE P2H-A" manufactured by Kyoeisha Chemical Co., Ltd.), and 10 parts of an acrylic oligomer ("ARFON UP-1190" manufactured by Toagosei Co., Ltd.), and 3 parts of "KAYACURE DETX-S" (manufactured by Nippon Kayaku Co., Ltd.) and 3 parts of OMNIRAD 907 (manufactured by IGM Resins Italia S.r.l.) serving as photopolymerization initiators were mixed to prepare an adhesive B.

[0066] [Example 1]

1. Production of Polarizing Plate

An amorphous polyethylene terephthalate (A-PET) film (manufactured by Mitsubishi Plastics, Inc., product name: NOVACLEAR SH046, thickness: 200 μm) was prepared as a substrate, and its surface was subjected to corona treatment (58 W/m²/min). Meanwhile, PVA (polymerization degree: 4,200, saponification degree: 99.2%) having added thereto 1 wt% of acetoacetyl-modified PVA (manufactured by the Nippon Synthetic Chemical Industry Co. Ltd., product name: Gohsefimer Z200, polymerization degree: 1,200, saponification degree: 99.0% or more, acetoacetyl modification degree: 4.6%) was prepared, and applied so as to have a film thickness after drying of 12 μm , followed by drying under a 60°C atmosphere by hot-air drying for 10 minutes to produce a laminate in which a PVA-based resin layer was formed on the substrate. Then, the laminate was first stretched in air at 130°C at a ratio of 2.0 times to provide a stretched laminate.

Next, there was performed a step of insolubilizing the PVA-based resin layer containing aligned PVA molecules included in the stretched laminate by immersing the stretched laminate in an insolubilizing aqueous solution of boric acid having a liquid temperature of 30°C for 30 seconds. In the insolubilizing aqueous solution of boric acid of this step, the boric acid content was set to 3 wt% with respect to 100 wt% of water. The resultant stretched laminate was dyed to produce a colored laminate. The colored laminate is a product obtained by immersing the stretched laminate in a dyeing liquid having a liquid temperature of 30°C and containing iodine and potassium iodide, to thereby adsorb iodine onto the PVA-based resin layer included in the stretched laminate. An iodine concentration and an immersion time were adjusted so that the polarizer to be obtained had a single layer transmittance of 44.5%. Specifically, in the dyeing liquid, water was used as a solvent, the iodine concentration was set to fall within the range of from 0.08 wt% to 0.25 wt%, and the potassium iodide concentration was set to fall within the range of from 0.56 wt% to 1.75 wt%. A ratio between the concentrations of iodine and potassium iodide was 1 to 7. Next, there was performed a step of subjecting the PVA molecules of the PVA-based resin layer onto which iodine had been adsorbed to cross-linking treatment by immersing the colored laminate in a cross-linking aqueous solution of boric acid at 30°C for 60 seconds. In the cross-linking aqueous

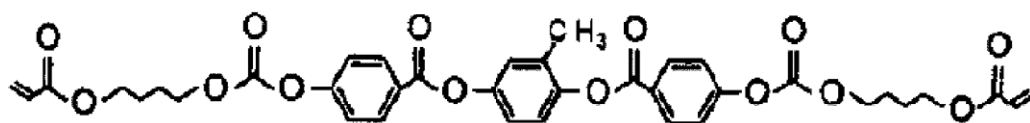
solution of boric acid of this step, the boric acid content was set to 3 wt% with respect to 100 wt% of water, and the potassium iodide content was set to 3 wt% with respect to 100 wt% of water. Further, the resultant colored laminate was stretched in an aqueous solution of boric acid at a stretching temperature of 70°C at a ratio of 2.7 times in the same direction as that of the stretching in the air, resulting in a final stretching ratio of 5.4 times. Thus, a laminate having the configuration "substrate/polarizer" was obtained. The thickness of the polarizer was 5 μm . In the aqueous solution of boric acid of this step, the boric acid content was set to 6.5 wt% with respect to 100 wt% of water, and the potassium iodide content was set to 5 wt% with respect to 100 wt% of water. The resultant laminate was taken out from the aqueous solution of boric acid, and boric acid adhering to the surface of the polarizer was washed off with an aqueous solution having a potassium iodide content of 2 wt% with respect to 100 wt% of water. The washed laminate was dried with warm air at 60°C.

A triacetylcellulose (TAC) film having a thickness of 40 μm was bonded to the surface of the polarizer of the laminate having the configuration "substrate/polarizer," which had been obtained in the foregoing, via a PVA-based adhesive to provide a laminate having the configuration "protective layer (TAC film)/polarizer/resin substrate." Further, the resin substrate

was peeled from the laminate, and another TAC film having a thickness of 40 μm was bonded to the peeled surface to provide a laminate (polarizing plate) having the configuration "protective layer (TAC film)/polarizer/protective layer (TAC film)."

[0067] 2. Production of Alignment Fixed Layer of Liquid Crystal Compound for forming 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 45° 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 1.5 μm and an in-plane retardation Re(550) of 140 nm. Further, the liquid crystal alignment fixed layer A had a refractive index distribution of $n_x > n_y = n_z$.

[0068] 3. Production of Polarizing Plate with Retardation Layer

The liquid crystal alignment fixed layer A obtained in the section 2. was transferred onto the surface of the polarizing plate obtained in the section 1. (substantially, one of the TAC films serving as protective layers) via the adhesive A (thickness after its curing: 1.0 μm) obtained in Production Example 1. Thus, a polarizing plate with a retardation layer having the configuration "protective layer (TAC film)/polarizer/protective layer (TAC film)/adhesive layer (adhesive A)/retardation layer (liquid crystal alignment fixed layer A, λ/4 plate, slow axis: direction of 45°)" was obtained. A section of the resultant polarizing plate with a retardation layer was observed with a

transmission electron microscope (TEM). As a result, permeation layers formed by the permeation of the adhesive A into both of the retardation layer (liquid crystal alignment fixed layer A) and the protective layer (TAC film) were observed. A TEM image for showing the state of an interface between the adhesive layer and the retardation layer (liquid crystal alignment fixed layer A) is shown in FIG. 4.

[0069] 4. Evaluation of Peelability

The resultant polarizing plate with a retardation layer was evaluated for its peelability. A method for the evaluation is specifically as described below. The resultant polarizing plate with a retardation layer was cut out into a size measuring 200 mm in a direction parallel to the absorption axis direction of the polarizer by 15 mm in a direction perpendicular thereto, and was bonded to a glass plate. The resultant was subjected to a peel test with a Tensilon universal tester RTC manufactured by A&D Company, Limited in a direction of 90° at a peel rate of 300 mm/min, and its peel strength at that time was measured. In the peel test, peeling occurred at an interface between the TAC film and the adhesive layer, and a peel strength therebetween was 0.8 N/15 mm.

[0070] [Example 2]

A polarizing plate with a retardation layer having the

configuration "protective layer (TAC film)/polarizer/protective layer (cycloolefin-based resin (COP) film)/adhesive layer (adhesive A)/retardation layer (liquid crystal alignment fixed layer A, $\lambda/4$ plate, slow axis: direction of 45°)" was obtained in the same manner as in Example 1 except that in the production of the polarizing plate, a COP film was bonded to the peeled surface of the resin substrate instead of the TAC film. A section of the resultant polarizing plate with a retardation layer was observed with a transmission electron microscope (TEM). As a result, a permeation layer formed by the permeation of the adhesive A into the retardation layer (liquid crystal alignment fixed layer A) was observed. Further, the resultant polarizing plate with a retardation layer was evaluated for its peelability in the same manner as in Example 1. In the peel test, peeling occurred at an interface between the retardation layer (liquid crystal alignment fixed layer A) and the adhesive layer, and a peel strength therebetween was 0.7 N/15 mm.

[0071] [Example 3]

A polarizing plate with a retardation layer having the configuration "protective layer (TAC film)/polarizer/protective layer (acrylic resin film)/adhesive layer (adhesive A)/retardation layer (liquid crystal alignment fixed layer A, $\lambda/4$ plate, slow axis: direction of 45°)" was obtained in the same manner as in Example 1 except that in the production of the

polarizing plate, an acrylic resin film was bonded to the peeled surface of the resin substrate instead of the TAC film. A section of the resultant polarizing plate with a retardation layer was observed with a transmission electron microscope (TEM). As a result, a permeation layer formed by the permeation of the adhesive A into the retardation layer (liquid crystal alignment fixed layer A) was observed. Further, the resultant polarizing plate with a retardation layer was evaluated for its peelability in the same manner as in Example 1. In the peel test, peeling occurred at an interface between the acrylic resin film and the adhesive layer, and a peel strength therebetween was 0.3 N/15 mm.

[0072] [Example 4]

A polarizing plate with a retardation layer having the configuration "protective layer (TAC film)/polarizer/adhesive layer (adhesive A)/retardation layer (liquid crystal alignment fixed layer A, $\lambda/4$ plate, slow axis: direction of 45°)" was obtained in the same manner as in Example 1 except that in the production of the polarizing plate, a protective layer was not arranged on the peeled surface of the resin substrate. A section of the resultant polarizing plate with a retardation layer was observed with a transmission electron microscope (TEM). As a result, a permeation layer formed by the permeation of the adhesive A into the retardation layer (liquid crystal alignment

fixed layer A) was observed. Further, the resultant polarizing plate with a retardation layer was evaluated for its peelability in the same manner as in Example 1. In the peel test, peeling did not occur.

[0073] [Example 5]

A polarizing plate having the configuration "protective layer (TAC film)/polarizer" was obtained in the same manner as in Example 4. Herein, a liquid crystal alignment fixed layer B was formed on the PET film in the same manner as in Example 1 except that: the application thickness was changed; and 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. The liquid crystal alignment fixed layer B had a thickness of $2.5\ \mu\text{m}$ and an in-plane retardation $\text{Re}(550)$ of $270\ \text{nm}$. The liquid crystal alignment fixed layer B was transferred onto the surface of the polarizer of the polarizing plate via the adhesive A (thickness after its curing: $1.0\ \mu\text{m}$). Further, a liquid crystal alignment fixed layer A, which was produced in the same manner as in Example 1 except that 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 the viewer side, was transferred onto the surface of the liquid crystal alignment fixed layer B via the adhesive A (thickness

after its curing: 1.0 μm). Thus, a polarizing plate with a retardation layer having the configuration "protective layer (TAC film)/polarizer/adhesive layer (adhesive A)/liquid crystal alignment fixed layer B ($\lambda/2$ plate, slow axis: direction of 15°)/adhesive layer (adhesive A)/liquid crystal alignment fixed layer A ($\lambda/4$ plate, slow axis: direction of 75°)" was obtained. A section of the resultant polarizing plate with a retardation layer was observed with a transmission electron microscope (TEM). As a result, permeation layers formed by the permeation of the adhesive A into both of the liquid crystal alignment fixed layer A and the liquid crystal alignment fixed layer B were observed. Further, the resultant polarizing plate with a retardation layer was evaluated for its peelability in the same manner as in Example 1. In the peel test, the cohesive failure of the adhesive layer between the liquid crystal alignment fixed layer A and the liquid crystal alignment fixed layer B occurred.

[0074] [Comparative Example 1]

A polarizing plate with a retardation layer having the configuration "protective layer (TAC film)/polarizer/adhesive layer (adhesive B)/retardation layer (liquid crystal alignment fixed layer A, $\lambda/4$ plate, slow axis: direction of 45°)" was obtained in the same manner as in Example 4 except that the adhesive B (thickness after its curing: 1.0 μm) obtained in Production Example 2 was used instead of the adhesive A. A

section of the resultant polarizing plate with a retardation layer was observed with a transmission electron microscope (TEM). As a result, no permeation layer was observed. A TEM image for showing the state of an interface between the adhesive layer and the retardation layer (liquid crystal alignment fixed layer A) is shown in FIG. 5. Further, the resultant polarizing plate with a retardation layer was evaluated for its peelability in the same manner as in Example 1. In the peel test, peeling occurred at an interface between the liquid crystal alignment fixed layer A and the adhesive layer, and a peel strength therebetween was 0.5 N/15 mm.

[0075] [Evaluation]

As is apparent from comparison between Examples and Comparative Example, according to Examples of the present invention, the peeling of the liquid crystal alignment fixed layer can be suppressed.

Industrial Applicability

[0076] The polarizing plate with a retardation layer 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

[0077] **10** polarizing plate

11 polarizer

12 first protective layer

13 second protective layer

20 retardation layer

20a permeation layer

21 first alignment fixed layer

21a permeation layer

22 second alignment fixed layer

22a permeation layer

31 first adhesive layer

32 second adhesive layer

100 polarizing plate with retardation layer

101 polarizing plate with retardation layer

102 polarizing plate with retardation layer

Claims

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

a polarizing plate including a polarizer and a protective layer arranged on at least one side of the polarizer;

a first adhesive layer; and

a retardation layer laminated on the polarizing plate via the first adhesive layer,

wherein the retardation layer is an alignment fixed layer of a liquid crystal compound, and includes a permeation layer, which is formed by permeation of an adhesive of the first adhesive layer into a vicinity of an interface thereof with the first adhesive layer.

[Claim 2] The polarizing plate with a retardation layer according to claim 1, wherein the polarizing plate includes the polarizer and the protective layer arranged on a side of the polarizer opposite to the retardation layer.

[Claim 3] The polarizing plate with a retardation layer according to claim 1, wherein the polarizing plate includes the polarizer and the protective layers arranged on both sides of the polarizer.

[Claim 4] The polarizing plate with a retardation layer according to claim 3, wherein the protective layer arranged on a

retardation layer side of the polarizer includes a permeation layer, which is formed by permeation of the adhesive of the first adhesive layer into a vicinity of an interface thereof with the first adhesive layer.

[Claim 5] The polarizing plate with a retardation layer according to any one of claims 1 to 4,

wherein the retardation layer is a single layer of the alignment fixed layer of the liquid crystal compound,

wherein the retardation layer has an $R_e(550)$ of from 100 nm to 190 nm, and

wherein a slow axis of the retardation layer and an absorption axis of the polarizer form an angle of from 40° to 50° .

[Claim 6] The polarizing plate with a retardation layer according to any one of claims 1 to 4,

wherein the retardation layer includes a first alignment fixed layer of a liquid crystal compound, and a second alignment fixed layer of a liquid crystal compound laminated on the first alignment fixed layer of the liquid crystal compound via a second adhesive layer,

wherein the first alignment fixed layer of the liquid crystal compound and the second alignment fixed layer of the liquid crystal compound each include a permeation layer, which

is formed by permeation of an adhesive of the second adhesive layer into a vicinity of an interface thereof with the second adhesive layer,

wherein the first alignment fixed layer of the liquid crystal compound has an $R_e(550)$ 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 alignment fixed layer of the liquid crystal compound has an $R_e(550)$ 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 7] The polarizing plate with a retardation layer according to any one of claims 1 to 6, wherein the adhesives of the first adhesive layer and the second adhesive layer each contain acryloylmorpholine.

[Claim 8] The polarizing plate with a retardation layer according to any one of claims 1 to 7, further comprising another retardation layer outside the retardation layer, wherein a refractive index characteristic of the another retardation layer shows a relationship of $n_z > n_x = n_y$.

[Claim 9] An image display apparatus, comprising the polarizing plate with a retardation layer of any one of claims 1 to 8.