

Description

Title of Invention: CIRCULAR POLARIZING PLATE AND IMAGE DISPLAY DEVICE

Technical Field

[0001] The present invention relates to a circularly polarizing plate and an image display apparatus.

Background Art

[0002] In recent years, along with widespread use of thin displays, an organic EL display apparatus having an organic EL panel has been proposed. The organic EL panel has a metal layer having high reflectivity, and hence is liable to cause a problem of, for example, reflection of ambient light or reflection of a background. In view of the foregoing, it has been known that such problem is prevented by arranging a circularly polarizing plate on a viewer side. In addition, it has been known that the circularly polarizing plate is arranged on the viewer side of a liquid crystal display panel to improve its viewing angle. However, the related-art circularly polarizing plate has a problem in that undesired coloring may occur in a reflection hue.

Citation List

Patent Literature

[0003] [PTL 1] JP 3325560 B2

Summary of Invention

Technical Problem

[0004] The present invention has been made in order to solve the problem of the related art described above, and a primary object of the present invention is to provide a circularly polarizing plate having a neutral reflection hue and an image display apparatus including such circularly polarizing plate.

Solution to Problem

[0005] According to one aspect of the present invention, there is provided a circularly polarizing plate, including: a polarizer; a retardation layer; and a pressure-sensitive adhesive layer, wherein an angle formed between an absorption axis of the polarizer and a slow axis of the retardation layer is from 39° to 51°, and wherein at least any one of the polarizer, the retardation layer, or the pressure-sensitive adhesive layer contains a dye compound having, in an absorption spectrum thereof, a maximum absorption wavelength in a wavelength region of 650 nm or more.

In one embodiment, in-plane retardations of the retardation layer satisfy $Re(450)/Re(550) > 1$.

In one embodiment, the in-plane retardations of the

retardation layer satisfy $1.1 > \text{Re}(450)/\text{Re}(550) > 1$.

In one embodiment, an in-plane retardation of the retardation layer satisfies $115 \text{ nm} \leq \text{Re}(550) \leq 135 \text{ nm}$.

In one embodiment, the pressure-sensitive adhesive layer contains the dye compound.

In one embodiment, the retardation layer is formed of a retardation film having an alicyclic structure.

According to another aspect of the present invention, there is provided an image display apparatus. The image display apparatus includes the circularly polarizing plate.

Advantageous Effects of Invention

[0006] According to the present invention, in the circularly polarizing plate including the polarizer, the retardation layer, and the pressure-sensitive adhesive layer, at least any one of the polarizer, the retardation layer, or the pressure-sensitive adhesive layer contains the dye compound having, in an absorption spectrum thereof, a maximum absorption wavelength in a wavelength region of 650 nm or more, and thus the circularly polarizing plate having a neutral reflection hue can be achieved.

Brief Description of Drawings

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

FIG. 2 is a schematic plan view for illustrating the entire configuration of an example of a stretching apparatus that may be used for the production of a retardation film.

FIG. 3 is a main portion schematic plan view for illustrating a link mechanism via which a clip pitch is changed in the stretching apparatus of FIG. 2, the view being an illustration of a state in which the clip pitch is minimum.

FIG. 4 is a main portion schematic plan view for illustrating the link mechanism via which the clip pitch is changed in the stretching apparatus of FIG. 2, the view being an illustration of a state in which the clip pitch is maximum.

FIG. 5 is a schematic view for illustrating oblique stretching in the production of the retardation film in one embodiment.

FIG. 6 is a graph for showing a relationship between each

zone of the stretching apparatus at the time of the oblique stretching illustrated in FIG. 5 and the clip pitch.

FIG. 7 is a graph for showing a relationship between each zone of the stretching apparatus at the time of oblique stretching in another embodiment and the clip pitch.

FIG. 8 is a schematic view for illustrating oblique stretching in the production of the retardation film in another embodiment.

FIG. 9 is a graph for showing a relationship between each zone of the stretching apparatus at the time of the oblique stretching illustrated in FIG. 8 and the clip pitch.

FIG. 10 is a schematic view for illustrating a relationship between the oblique stretching in the production of the retardation film and the equation (1).

FIG. 11 is a schematic view for illustrating the respective moving speeds of left and right clips in oblique stretching in the production of the retardation film in one embodiment, and the equation (1).

FIG. 12 is a schematic view for illustrating the respective

moving speeds of left and right clips in oblique stretching in the production of the retardation film in another embodiment, and the equation (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 (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 " $Re=(n_x-n_y)\times d$ " when the thickness of a layer (film) is represented by d (nm).

[0010] A. Circularly Polarizing Plate

FIG. 1 is a schematic sectional view of a circularly polarizing plate according to one embodiment of the present invention. A circularly polarizing plate **100** includes a polarizer **10**, a retardation layer **20**, and a pressure-sensitive adhesive layer **30**. An angle formed between the absorption axis of the polarizer **10** and the slow axis of the retardation layer **20** is from 39° to 51°. At least any one of the polarizer **10**, the retardation layer **20**, or the pressure-sensitive adhesive layer **30** contains a dye compound having, in an absorption spectrum thereof, a maximum absorption wavelength in a wavelength region of 650 nm or more. Accordingly, the reflection hue of the circularly polarizing plate can be made closer to a neutral one. In the example illustrated in FIG. 1, the polarizer **10**, the retardation layer **20**, and the pressure-sensitive adhesive layer **30** are laminated in the stated order. However, the configuration of the circularly polarizing plate **100** is not limited to the configuration of the illustrated example. For example, the circularly polarizing plate **100** may include a protective layer for the polarizer **10**, and/or another retardation layer besides the retardation layer **20**. Further,

the circularly polarizing plate **100** may include a plurality of pressure-sensitive adhesive layers, and the pressure-sensitive adhesive layers may be arranged at any appropriate positions. In one embodiment, at least any one pressure-sensitive adhesive layer out of the pressure-sensitive adhesive layers included in the circularly polarizing plate **100** contains the dye compound. The in-plane retardation of the retardation layer **20** preferably satisfies $115 \text{ nm} \leq R_e(550) \leq 135 \text{ nm}$. In one embodiment, the retardation layer **20** is formed of a retardation film having an alicyclic structure.

[0011] The in-plane retardations of the retardation layer preferably satisfy a relationship of $R_e(450)/R_e(550) > 1$. That is, the retardation layer shows such a positive wavelength dispersion characteristic that its in-plane retardation value reduces with an increase in wavelength of measurement light, or such a flat wavelength dispersion characteristic that the in-plane retardation value hardly changes irrespective of the wavelength of the measurement light. The in-plane retardations of the retardation layer more preferably satisfy a relationship of $1.1 > R_e(450)/R_e(550) > 1$. That is, the retardation layer shows the flat wavelength dispersion characteristic. A retardation layer showing the positive wavelength dispersion characteristic or the flat wavelength dispersion characteristic can be reduced in thickness for achieving a desired in-plane retardation value

as compared to a retardation layer showing a reverse wavelength dispersion characteristic. In this connection, the bending elasticity of a circularly polarizing plate is inversely proportional to the cube of the thickness of the circularly polarizing plate, and hence the circularly polarizing plate has more excellent bending resistance as its thickness becomes smaller. Therefore, a circularly polarizing plate using the retardation layer showing the positive wavelength dispersion characteristic or the flat wavelength dispersion characteristic has a small thickness, and hence has excellent bending resistance. Such circularly polarizing plate can be suitably used for a bendable image display apparatus. In addition, in general, the retardation layer showing the positive wavelength dispersion characteristic or the flat wavelength dispersion characteristic sometimes causes undesired coloring in a reflection hue as compared to the retardation layer showing the reverse wavelength dispersion characteristic. However, as described above, when any one of the layers included in the circularly polarizing plate contains the dye compound, the reflection hue can be made closer to a neutral one. Therefore, the circularly polarizing plate according to this embodiment has excellent bending resistance, and besides, can achieve a neutral reflection hue.

[0012] B. Dye Compound

As described above, the dye compound has, in an absorption

spectrum thereof, a maximum absorption wavelength in a wavelength region of 650 nm or more. The maximum absorption wavelength in the absorption spectrum of the dye compound is preferably in a wavelength region of from 650 nm to 750 nm, more preferably in a wavelength region of from 670 nm to 730 nm. The use of such dye compound can make the reflection hue of the circularly polarizing plate closer to a neutral one while suppressing a reduction in visible light transmittance of the circularly polarizing plate. As a result of the suppression of the reduction in visible light transmittance of the circularly polarizing plate, a reduction in white brightness can be suppressed in the case where the circularly polarizing plate is used for an image display apparatus.

[0013] The absorption half-width of the dye compound is preferably 120 nm or less, more preferably from 5 nm to 110 nm. The absorption half-width of the dye compound may be measured from a transmission/absorption spectrum of a solution of the dye compound with a UV-visible spectrophotometer (U-4100, manufactured by Hitachi High-Tech Science Corporation) under the following measurement conditions. Typically, on the basis of an optical spectrum measured at such an adjusted concentration that the absorbance at the maximum absorption wavelength is 1.0, a distance (full width at half maximum) in wavelength between two points corresponding to 50% of a peak value is adopted as the

absorption half-width of the dye compound.

(Measurement Conditions)

Solvent: toluene or chloroform

Cell: quartz cell

Optical path length: 10 mm

[0014] The dye compound only needs to be a compound having, in an absorption spectrum thereof, a maximum absorption wavelength in the above-mentioned wavelength region, and its structure and the like are not particularly limited. Examples of the dye compound may include an organic dye compound and an inorganic dye compound. Of those, an organic dye compound is preferred from the viewpoints of dispersibility and the maintenance of transparency. The dye compounds may be used alone or as a mixture thereof.

[0015] Examples of the dye compound may include imonium-based, nickel dithiol-based, phthalocyanine-based, cyanine-based, azo-based, quinophthalone-based, indigo-based, and porphyrin-based compounds.

[0016] A commercially available product may be suitably used as the dye compound, and specific examples thereof may include FDR-003 (manufactured by Yamada Chemical Co., Ltd.) and

FDR-004 (manufactured by Yamada Chemical Co., Ltd.), which are phthalocyanine-based compounds. Details of the dye compound are described in, for example, JP 2016-188357 A, the description of which is incorporated herein by reference.

[0017] When the pressure-sensitive adhesive layer contains the dye compound, the content of the dye compound in the pressure-sensitive adhesive layer is preferably from 0.01 part by weight to 10 parts by weight, more preferably from about 0.05 part by weight to about 5 parts by weight with respect to 100 parts by weight of a pressure-sensitive adhesive forming the pressure-sensitive adhesive layer. When the addition amount of the dye compound is set to fall within the above-mentioned ranges, the reflection hue of the circularly polarizing plate can be made closer to a neutral one while a reduction in visible light transmittance of the circularly polarizing plate is suppressed.

[0018] C. Retardation Layer

As described above, the in-plane retardations of the retardation layer preferably satisfy a relationship of $\text{Re}(450)/\text{Re}(550) > 1$, and more preferably satisfy a relationship of $1.1 > \text{Re}(450)/\text{Re}(550) > 1$.

[0019] The in-plane retardation of the retardation layer preferably satisfies $115 \text{ nm} \leq \text{Re}(550) \leq 135 \text{ nm}$. The $\text{Re}(550)$ of the

retardation layer is more preferably from 118 nm to 132 nm, still more preferably from 120 nm to 130 nm.

[0020] The thickness of the retardation layer is preferably from 1 μm to 50 μm , more preferably from 2 μm to 40 μm , still more preferably from 3 μm to 30 μm .

[0021] The retardation layer is typically formed of a retardation film that satisfies the above-mentioned characteristics. The retardation film may be formed by stretching any appropriate resin film. In one embodiment, the resin for forming the retardation film has an alicyclic structure. Examples of the resin for forming the retardation film include a polycarbonate-based resin, a cyclic olefin-based resin, a cellulose-based resin, a polyester-based resin, a polyvinyl alcohol-based resin, a polyamide-based resin, a polyimide-based resin, a polyether-based resin, a polystyrene-based resin, an acrylic resin, and a polyester carbonate resin. Of those, a polycarbonate-based resin or a cyclic olefin-based resin may be suitably used.

[0022] Any appropriate polycarbonate resin may be used as the polycarbonate-based resin as long as the effect of the present invention is obtained. The polycarbonate resin preferably contains a structural unit derived from an

isosorbide-based dihydroxy compound, and a structural unit derived from at least one dihydroxy compound selected from the group consisting of an alicyclic diol, an alicyclic dimethanol, di-, tri-, or polyethylene glycol, and an alkylene glycol or spiroglycol. The polycarbonate resin more preferably contains a structural unit derived from an isosorbide-based dihydroxy compound, and a structural unit derived from an alicyclic dimethanol and/or a structural unit derived from di-, tri-, or polyethylene glycol. The polycarbonate resin may contain a structural unit derived from any other dihydroxy compound as required. Details of methods of producing the polycarbonate resin and the retardation film that may be suitably used in the present invention are described in, for example, WO 2011/062239 A1, the description of which is incorporated herein by reference.

[0023] The cyclic olefin-based resin is a generic term for resins each polymerized by using a cyclic olefin as a polymerization unit, and examples thereof include resins described in JP 01-240517 A, JP 03-14882 A, and JP 03-122137 A. Specific examples thereof include: a ring-opened (co)polymer of the cyclic olefin, an addition polymer of the cyclic olefin, a copolymer (typically a random copolymer) of the cyclic olefin and an α -olefin, such as ethylene or propylene, and graft-modified products obtained by modifying those polymers with unsaturated carboxylic acids or derivatives thereof; and

hydrogenated products thereof. A specific example of the cyclic olefin is a norbornene-based monomer. Examples of the norbornene-based monomer include monomers described in JP 2015-210459 A and the like. The cyclic olefin-based resin is commercially available as various products. Specific examples thereof include products available under the product names "ZEONEX" and "ZEONOR" from Zeon Corporation, a product available under the product name "Arton" from JSR Corporation, a product available under the product name "TOPAS" from TICONA, and a product available under the product name "APEL" from Mitsui Chemicals, Inc.

[0024] Any appropriate method including a step of stretching a resin film may be adopted as a method of producing the retardation film. As a method for the stretching, there are given, for example, lateral uniaxial stretching (fixed-end biaxial stretching), sequential biaxial stretching, and oblique stretching. A stretching temperature is preferably from 125°C to 160°C, more preferably from 130°C to 150°C.

[0025] In one embodiment, the retardation film is produced by subjecting the resin film to uniaxial stretching or fixed-end uniaxial stretching. A specific example of the fixed-end uniaxial stretching is a method involving stretching the resin film in its widthwise direction (lateral direction) while

running the resin film in its lengthwise direction. A stretching ratio is preferably from 1.1 times to 3.5 times.

[0026] In another embodiment, the retardation film is produced by continuously subjecting an elongate resin film to oblique stretching in a direction at an angle θ with respect to its lengthwise direction. When the oblique stretching is adopted, an elongate stretched film having an alignment angle that is the angle θ with respect to the lengthwise direction of the film (a slow axis in the direction at the angle θ) is obtained. As a result, for example, a roll-to-roll process can be performed at the time of its lamination with the polarizer, and hence a production process can be simplified.

[0027] As a stretching machine to be used for the oblique stretching, there is given, for example, a tenter stretching machine capable of applying feeding forces, or tensile forces or take-up forces, having different speeds on left and right sides in a lateral direction and/or a longitudinal direction. Examples of the tenter stretching machine include a lateral uniaxial stretching machine and a simultaneous biaxial stretching machine, and any appropriate stretching machine may be used as long as the elongate resin film can be continuously subjected to the oblique stretching.

[0028] A method of producing the retardation film by the oblique stretching may include: holding left and right end portions of a film with left and right variable pitch-type clips configured to have clip pitches changing in a longitudinal direction, respectively (holding step); preheating the film (preheating step); increasing the clip pitch of the clips on one side and reducing the clip pitch of the clips on another side, while extending a distance between the left and right clips, to obliquely stretch the film (first oblique stretching step); maintaining or reducing the clip pitch of the clips on the one side and increasing the clip pitch of the clips on the another side so that the clip pitches of the left and right clips are equal to each other, while extending the distance between the left and right clips, to obliquely stretch the film (second oblique stretching step); and releasing the clips holding the film (releasing step). Now, the respective steps are described in detail.

[0029] C-1. Holding Step

First, a stretching apparatus that may be used in the method of producing the retardation film including this step is described with reference to FIG. 2 to FIG. 4. FIG. 2 is a schematic plan view for illustrating the entire construction of an example of the stretching apparatus that may be used in the method of producing the retardation film. FIG. 3 and FIG. 4 are

each a main portion schematic plan view for illustrating a link mechanism via which a clip pitch is changed in the stretching apparatus of FIG. 2, FIG. 3 being an illustration of a state in which the clip pitch is minimum and FIG. 4 being an illustration of a state in which the clip pitch is maximum. When viewed in plan view, a stretching apparatus **100** has, on both of its left and right sides, an endless loop **10L** and an endless loop **10R** each having many clips **20** for holding a film so that the loops may be bilaterally symmetric with each other. In this description, an endless loop on a left side when viewed from a film inlet side is referred to as "left endless loop **10L**" and an endless loop on a right side is referred to as "right endless loop **10R**." Each of the clips **20** of the left and right endless loops **10L** and **10R** is guided by a reference rail **70** to cyclically move in a loop manner. The left endless loop **10L** cyclically moves in a counterclockwise direction and the right endless loop **10R** cyclically moves in a clockwise direction. In the stretching apparatus, a holding zone **A**, a preheating zone **B**, a first oblique stretching zone **C**, a second oblique stretching zone **D**, and a releasing zone **E** are arranged in the stated order from a sheet inlet side toward a sheet outlet side. Those zones mean zones in which the film to be stretched is substantially held, preheated, subjected to first oblique stretching and second oblique stretching, and released, respectively, and do not mean mechanically or structurally independent sections. In addition,

attention should be paid to the fact that a ratio among the lengths of the respective zones in the stretching apparatus of FIG. 2 is different from the actual length ratio.

[0030] In the holding zone **A** and the preheating zone **B**, the right and left endless loops **10R** and **10L** are configured to be substantially parallel to each other while being separated from each other by a distance corresponding to the initial width of the film to be stretched. In the first oblique stretching zone **C** and the second oblique stretching zone **D**, the right and left endless loops **10R** and **10L** are configured so that the distance by which the loops are separated from each other may gradually enlarge from the preheating zone **B** side toward the releasing zone **E** until the distance corresponds to the width of the film after its stretching. In the releasing zone **E**, the right and left endless loops **10R** and **10L** are configured to be substantially parallel to each other while being separated from each other by a distance corresponding to the width of the film after the stretching.

[0031] The clips (left clips) **20** of the left endless loop **10L** and the clips (right clips) **20** of the right endless loop **10R** can each independently cyclically move. For example, driving sprockets **11** and **12** of the left endless loop **10L** are rotationally driven in the counterclockwise direction by electric motors **13**

and **14**, and the driving sprockets **11** and **12** of the right endless loop **10R** are rotationally driven in the clockwise direction by the electric motors **13** and **14**. As a result, a running force is imparted to a clip-carrying member **30** of each of drive rollers (not shown) engaging with the driving sprockets **11** and **12**. Thus, the left endless loop **10L** cyclically moves in the counterclockwise direction and the right endless loop **10R** cyclically moves in the clockwise direction. The left endless loop **10L** and the right endless loop **10R** can each independently be cyclically moved by each independently driving a left electric motor and a right electric motor.

[0032] Further, the clips (left clips) **20** of the left endless loop **10L** and the clips (right clips) **20** of the right endless loop **10R** are each of a variable pitch type. That is, the clip pitches (clip-to-clip distances) of the left and right clips **20** and **20** in the longitudinal direction (MD) can each independently change along with their movement. The variable pitch type may be realized by any appropriate configuration. Now, description is given by taking a link mechanism (pantograph mechanism) as an example.

[0033] As illustrated in FIG. **3** and FIG. **4**, the elongated rectangular clip-carrying members **30** are arranged in a lateral direction in a planar view by which the clips **20** are individually

carried. Although not shown, the clip-carrying members **30** are each formed so as to be of a frame structure closed by an upper beam, a lower beam, a front wall (wall on the clip side), and a rear wall (wall on a side opposite to the clip), and having a strong section. The clip-carrying members **30** are each arranged so as to roll on running road surfaces **81** and **82** by virtue of running wheels **38** on both of its ends. In FIG. **3** and FIG. **4**, a running wheel on the front wall side (running wheel rolling on the running road surface **81**) is not shown. The running road surfaces **81** and **82** are parallel to the reference rail **70** over an entire region. On the rear sides (sides opposite to the clip) of the upper beam and lower beam of each of the clip-carrying members **30**, a long hole **31** is formed along the lengthwise direction of the clip-carrying member and a slider **32** engages slidably in the lengthwise direction of the long hole **31**. One first axis member **33** is vertically arranged near an end portion of each of the clip-carrying members **30** on the clip **20** side so as to penetrate its upper beam and lower beam. Meanwhile, one second axis member **34** is vertically arranged so as to penetrate the slider **32** of each of the clip-carrying members **30**. One end of a main link member **35** is pivotally linked to the first axis member **33** of each of the clip-carrying members **30**. The other end of the main link member **35** is pivotally linked to the second axis member **34** of the adjacent clip-carrying member **30**. In addition to the main link member **35**, one end of a sub-link member

36 is pivotally linked to the first axis member **33** of each of the clip-carrying members **30**. The other end of the sub-link member **36** is pivotally linked to the central portion of the main link member **35** by a pivot **37**. By virtue of the link mechanism based on the main link member **35** and the sub-link member **36**, as the extent to which the slider **32** moves toward the rear side of the clip-carrying member **30** (side opposite to the clip side) becomes larger as illustrated in FIG. **3**, a pitch between the clip-carrying members **30** in the longitudinal direction (hereinafter simply referred to as "clip pitch") reduces, and as the extent to which the slider **32** moves toward the front side of the clip-carrying member **30** (clip side) becomes larger as illustrated in FIG. **4**, the clip pitch increases. The positioning of the slider **32** is performed by a pitch-setting rail **90**. As illustrated in FIG. **3** and FIG. **4**, as the clip pitch becomes larger, the distance by which the reference rail **70** and the pitch-setting rail **90** are separated from each other reduces. The link mechanism is well known in the art, and hence more detailed description thereof is omitted.

[0034] When the film is obliquely stretched with such stretching apparatus as described above, there can be produced a retardation film having a slow axis in an oblique direction (e.g., a direction at 45° with respect to the longitudinal direction). First, in the holding zone **A** (inlet of film intake

by the stretching apparatus **100**), both side edges of the film to be stretched are held with the clips **20** of the right and left endless loops **10R** and **10L** at constant clip pitches equal to each other, and the film is fed to the preheating zone **B** by the movement of the right and left endless loops **10R** and **10L** (substantially the movement of each of the clip-carrying members **30** guided by the reference rail **70**).

[0035] C-2. Preheating Step

In the preheating zone (preheating step) **B**, as described above, the right and left endless loops **10R** and **10L** are configured to be substantially parallel to each other while being separated from each other by a distance corresponding to the initial width of the film to be stretched, and hence the film is basically heated without being laterally stretched or longitudinally stretched. However, a distance between the left and right clips (distance in a widthwise direction) may be slightly widened in order to avoid, for example, the following inconvenience: the film sags owing to the preheating to be brought into contact with a nozzle in an oven.

[0036] In the preheating step, the film is heated to a temperature T_1 ($^{\circ}\text{C}$). The temperature T_1 is preferably equal to or more than the glass transition temperature (T_g) of the film, more preferably equal to or more than $T_g+2^{\circ}\text{C}$, still more

preferably equal to or more than $T_g+5^{\circ}\text{C}$. Meanwhile, the heating temperature T_1 is preferably equal to or less than $T_g+40^{\circ}\text{C}$, more preferably equal to or less than $T_g+30^{\circ}\text{C}$. The temperature T_1 is, for example, from 70°C to 190°C , preferably from 80°C to 180°C , though the temperature varies depending on the film to be used.

[0037] A time period required for the temperature of the film to be increased to the temperature T_1 and a time period for which the temperature is held at the temperature T_1 may be appropriately set depending on a constituent material for the film and a condition under which the film is produced (e.g., the speed at which the film is conveyed). The temperature increase time period and the holding time period may be controlled by adjusting, for example, the moving speeds of the clips **20**, the length of the preheating zone, and the temperature of the preheating zone.

[0038] C-3. First Oblique Stretching Step

In the first oblique stretching zone (first oblique stretching step) **C**, the film is obliquely stretched by increasing the clip pitch of the clips on one side and reducing the clip pitch of the clips on the other side while extending the distance between the left and right clips (more specifically, the distance by which the right and left endless loops **10R** and **10L** are

separated from each other). When the clip pitches are changed as described above, the left and right clips are moved at different speeds, whereby the oblique stretching can be performed while one side edge portion of the film is elongated in its lengthwise direction and the other side edge portion of the film is shrunk in the lengthwise direction. As a result, a slow axis can be expressed in a desired direction (e.g., a direction at 45° relative to the lengthwise direction) with high uniaxiality and a high in-plane alignment property.

[0039] One embodiment of the first oblique stretching is hereinafter specifically described with reference to FIG. 5 and FIG. 6. First, in the preheating zone **B**, both the left and right clip pitches are set to **P₁**. **P₁** represents a clip pitch upon holding of the film. Next, simultaneously with the entry of the film into the first oblique stretching zone **C**, the increase of the clip pitch of the clips on one side (right side in the illustrated example) is started and the reduction of the clip pitch of the clips on the other side (left side in the illustrated example) is started. In the first oblique stretching zone **C**, the clip pitch of the right clips is increased to **P₂** and the clip pitch of the left clips is reduced to **P₃**. Therefore, in the terminating portion of the first oblique stretching zone **C** (starting portion of the second oblique stretching zone **D**), the left clips move at the clip pitch **P₃** and the right clips move

at the clip pitch P_2 . A ratio between the clip pitches may generally correspond to a ratio between the moving speeds of the clips. Accordingly, the ratio between the clip pitches of the left and right clips may generally correspond to a ratio between the stretching ratios of the right side edge portion and left side edge portion of the film in the MD direction.

[0040] In FIG. 5 and FIG. 6, both the position at which the clip pitch of the right clips starts to increase and the position at which the clip pitch of the left clips starts to reduce are each defined as the starting portion of the first oblique stretching zone **C**. However, unlike the illustrated example, the clip pitch of the left clips may start to reduce after the clip pitch of the right clips has started to increase (e.g., FIG. 7), or the clip pitch of the right clips may start to increase after the clip pitch of the left clips has started to reduce (not shown). In one preferred embodiment, after the clip pitch of the clips on one side has started to increase, the clip pitch of the clips on the other side starts to reduce. According to such embodiment, the film has already been stretched in the widthwise direction to a certain extent (preferably from about 1.2 times to 2.0 times), and hence a wrinkle hardly occurs even when the clip pitch on the other side is largely reduced. Accordingly, the oblique stretching can be performed at an additionally acute angle, and hence a retardation film having high uniaxiality and

a high in-plane alignment property can be suitably obtained.

[0041] Similarly, in FIG. 5 and FIG. 6, the increase of the clip pitch of the right clips and the reduction of the clip pitch of the left clips continue up to the terminating portion of the first oblique stretching zone **C** (starting portion of the second oblique stretching zone **D**), but unlike the illustrated example, the following is permitted: one of the increase and reduction of the clip pitches ends before the terminating portion of the first oblique stretching zone **C**, and the clip pitch is maintained as it is up to the terminating portion of the first oblique stretching zone **C**.

[0042] The change ratio (P_2/P_1) of the clip pitch to be increased is preferably from 1.25 to 1.75, more preferably from 1.30 to 1.70, still more preferably from 1.35 to 1.65. In addition, the change ratio (P_3/P_1) of the clip pitch to be reduced is, for example, 0.50 or more and less than 1, preferably from 0.50 to 0.95, more preferably from 0.55 to 0.90, still more preferably from 0.55 to 0.85. When the change ratios of the clip pitches fall within such ranges, a slow axis can be expressed in a direction at generally 45° relative to the lengthwise direction of the film with high uniaxiality and a high in-plane alignment property.

[0043] As described above, the clip pitches may be adjusted by positioning the sliders through the adjustment of the distance by which the pitch-setting rail and reference rail of the stretching apparatus are separated from each other.

[0044] The stretching ratio (W_2/W_1) of the film in the widthwise direction in the first oblique stretching step is preferably from 1.1 times to 3.0 times, more preferably from 1.2 times to 2.5 times, still more preferably from 1.25 times to 2.0 times. When the stretching ratio is less than 1.1 times, a corrugated galvanized iron-like wrinkle may occur in the side edge portion on the shrunk side. In addition, when the stretching ratio is more than 3.0 times, the biaxiality of the retardation film to be obtained is raised, and hence in the case where the film is applied to a circularly polarizing plate or the like, its viewing angle characteristic may reduce.

[0045] In one embodiment, the first oblique stretching is performed so that the product of the change ratio of the clip pitch of the clips on one side and the change ratio of the clip pitch of the clips on the other side may be preferably from 0.7 to 1.5, more preferably from 0.8 to 1.45, still more preferably from 0.85 to 1.40. When the product of the change ratios falls within such ranges, a retardation film having high uniaxiality and a high in-plane alignment property can be obtained.

[0046] The first oblique stretching can be typically performed at a temperature T_2 . The temperature T_2 is preferably from $T_g - 20^\circ\text{C}$ to $T_g + 30^\circ\text{C}$ where T_g represents the glass transition temperature of the resin film, more preferably from $T_g - 10^\circ\text{C}$ to $T_g + 20^\circ\text{C}$, particularly preferably about T_g . The temperature T_2 is, for example, from 70°C to 180°C , preferably from 80°C to 170°C , though the temperature varies depending on the resin film to be used. A difference ($T_1 - T_2$) between the temperature T_1 and the temperature T_2 is preferably $\pm 2^\circ\text{C}$ or more, more preferably $\pm 5^\circ\text{C}$ or more. In one embodiment, $T_1 > T_2$ and hence the film heated to the temperature T_1 in the preheating step may be cooled to the temperature T_2 .

[0047] C-4. Second Oblique Stretching Step

In the second oblique stretching zone (second oblique stretching step) **D**, the film is obliquely stretched by maintaining or reducing the clip pitch of the clips on one side and increasing the clip pitch of the clips on the other side so that the clip pitches of the left and right clips are equal to each other, while extending the distance between the left and right clips (more specifically, the distance by which the right and left endless loops **10R** and **10L** are separated from each other). When the oblique stretching is performed while the difference between the left and right clip pitches is reduced as described

above, the film can be sufficiently stretched in an oblique direction while an excess stress is alleviated. In addition, the film can be subjected to the releasing step in a state where the moving speeds of the left and right clips are equal to each other, and hence a variation in, for example, speed at which the film is conveyed hardly occurs at the time of the release of the left and right clips, and subsequent take-up of the film can be suitably performed.

[0048] One embodiment of the second oblique stretching is hereinafter specifically described with reference to FIG. 5 and FIG. 6. First, the increase of the clip pitch of the left clips is started simultaneously with the entry of the film into the second oblique stretching zone **D**. In the second oblique stretching zone **D**, the clip pitch of the left clips is increased to P_2 . Meanwhile, the clip pitch of the right clips is maintained at P_2 in the second oblique stretching zone **D**. Therefore, in the terminating portion of the second oblique stretching zone **D** (starting portion of the releasing zone **E**), both the left clips and the right clips move at the clip pitch P_2 .

[0049] The change ratio (P_2/P_3) of the clip pitch to be increased in the embodiment is not limited as long as a retardation film having desired optical characteristics can be obtained. The change ratio (P_2/P_3) is, for example, from 1.3 to

4.0, preferably from 1.5 to 3.0.

[0050] Next, another embodiment of the second oblique stretching is specifically described with reference to FIG. 8 and FIG. 9. First, simultaneously with the entry of the film into the second oblique stretching zone **D**, the reduction of the clip pitch of the right clips is started and the increase of the clip pitch of the left clips is started. In the second oblique stretching zone **D**, the clip pitch of the right clips is reduced to P_4 and the clip pitch of the left clips is increased to P_4 . Therefore, in the terminating portion of the second oblique stretching zone **D** (starting portion of the releasing zone **E**), both the left clips and the right clips move at the clip pitch P_4 . In the illustrated example, for simplicity, both the position at which the clip pitch of the right clips starts to reduce and the position at which the clip pitch of the left clips starts to increase are each defined as the starting portion of the second oblique stretching zone **D**, but these positions may be different positions. Similarly, the position at which the reduction of the clip pitch of the right clips ends and the position at which the increase of the clip pitch of the left clips ends may be different positions.

[0051] The change ratio (P_4/P_2) of the clip pitch to be reduced in the embodiment and the change ratio (P_4/P_3) of the

clip pitch to be increased therein are not limited as long as the effects of the present invention are not impaired. The change ratio (P_4/P_2) is, for example, 0.4 or more and less than 1.0, preferably from 0.6 to 0.95. In addition, the change ratio (P_4/P_3) is, for example, more than 1.0 and 2.0 or less, preferably from 1.2 to 1.8. The P_4 is preferably equal to or more than the P_1 . When $P_4 < P_1$, a problem such as the occurrence of a wrinkle in a side end portion or an increase in biaxiality may occur.

[0052] The stretching ratio (W_3/W_2) of the film in the widthwise direction in the second oblique stretching step is preferably from 1.1 times to 3.0 times, more preferably from 1.2 times to 2.5 times, still more preferably from 1.25 times to 2.0 times. When the stretching ratio is less than 1.1 times, a corrugated galvanized iron-like wrinkle may occur in the side edge portion on the shrunk side. In addition, when the stretching ratio is more than 3.0 times, the biaxiality of the retardation film to be obtained is raised, and hence in the case where the film is applied to a circularly polarizing plate or the like, its viewing angle characteristic may reduce. In addition, a stretching ratio (W_3/W_1) in the widthwise direction in the first oblique stretching step and the second oblique stretching step is preferably from 1.2 times to 4.0 times, more preferably from 1.4 times to 3.0 times from the same viewpoints as those described above.

[0053] In one embodiment, the first oblique stretching and the second oblique stretching are performed so that an oblique stretching ratio determined from the following equation (1) may be preferably 2.0 or more, more preferably from 2.0 to 4.0, still more preferably from 2.5 to 3.5. When the oblique stretching ratio is less than 2.0, the biaxiality of the retardation film may be raised or its in-plane alignment property may reduce.

[0054]

$$S = \sqrt{W_3^2 + (v3' * (t3 - t3'))^2} / W_1 \quad \text{Equation (1)}$$

(In the equation:

W_1 represents the width of the film before the first oblique stretching;

W_3 represents the width of the film after the second oblique stretching;

$v3'$ represents the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clip pitch of the clips changes to a predetermined clip pitch in the second oblique stretching step;

$t3$ represents a time period from the entry of the clips having a clip pitch to be reduced in the first oblique stretching step into the preheating zone to the end of the second oblique

stretching step; and

t_3' represents a time period from the entry of the clips having a clip pitch to be increased in the first oblique stretching step into the preheating zone to the end of the second oblique stretching step.)

[0055] With regard to the v_3' , the predetermined clip pitch means a clip pitch after the maintenance or reduction of the clip pitch in the second oblique stretching step following the completion of the increase of the clip pitch in the first oblique stretching step, and corresponds to the P_2 or P_4 in the description of the section C-3. In addition, when the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clip pitch of the clips is changed to the predetermined clip pitch (corresponding to the P_2 in the description of the section C-3) in the first oblique stretching step is represented by v_2' ,

in the case where $v_2' = v_3'$, the t_3 is represented by the following equation (2) and the t_3' is represented by the following equation (3), and

in the case where $v_2' > v_3'$, the t_3 is represented by the following equation (4) and the t_3' is represented by the following equation (5).

[0056] The equations (2) to (4) are hereinafter described.

In the description of the respective symbols in the equations, reference may be made to FIGS. **10** to **12**. An asterisk mark (*) in each of the equations (1) to (5) is a multiplication sign. In addition, the unit of a film width is m, the unit of a velocity is m/sec, the unit of a distance is m, and the unit of a time period is sec.

[0057]

$$t_3 = (1/a_1) \cdot \ln(a_1 \cdot L_3 + b_1) - (1/a_1) \cdot \ln(a_1 \cdot L_2 + b_1) + (1/a) \cdot \ln(a \cdot L_2 + b) - (1/a) \cdot \ln(a \cdot L_1 + b) + L_1/v_1 \quad \text{Equation (2)}$$

(In the equation:

$$a_1 = (v_2 - v_3) / (L_2 - L_3);$$

$$b_1 = v_3 - a_1 \cdot L_3;$$

$$a = (v_1 - v_2) / (L_1 - L_2);$$

$$b = v_2 - a \cdot L_2;$$

v1 represents the moving speed of the clips having a clip pitch to be reduced in the first oblique stretching step when the clips pass the preheating zone;

v2 represents the moving speed of the clips having a clip pitch to be reduced in the first oblique stretching step when the clip pitch of the clips is reduced to a predetermined clip pitch (corresponding to the **P₃** in the description of the section C-3) in the first oblique stretching step;

v3 represents the moving speed of the clips having a clip pitch to be reduced in the first oblique stretching step when

the clip pitch of the clips is increased to a predetermined clip pitch (corresponding to the P_2 or P_4 in the description of the section C-3) in the second oblique stretching step;

L1 represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be reduced in the first oblique stretching step start to reduce the clip pitch (in one embodiment, a distance from the inlet of the preheating zone to the outlet of the preheating zone);

L2 represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be reduced in the first oblique stretching step start to increase the clip pitch (in one embodiment, a distance from the inlet of the preheating zone to the outlet of the first oblique stretching zone); and

L3 represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be reduced in the first oblique stretching step end the increase of the clip pitch (in one embodiment, a distance from the inlet of the preheating zone to the outlet of the second oblique stretching zone).)

[0058]

$$t3' = (L1'/v1') + (1/a') * \ln(a' * L2' + b') - (1/a') * \ln(a' * L1' + b') + (L3' - L2')/v3' \quad \text{Equation (3)}$$

(In the equation:

$$a' = (v1' - v2') / (L1' - L2');$$

$$b' = v3' - a' * L2';$$

v1' represents the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clips pass the preheating zone;

v2' represents the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clip pitch of the clips is increased to a predetermined clip pitch (corresponding to the **P₂** in the description of the section C-3) in the first oblique stretching step;

v3' represents the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clips pass the second oblique stretching zone;

L1' represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be increased in the first oblique stretching step start to increase the clip pitch (in one embodiment, a distance from the inlet of the preheating zone to the outlet of the preheating zone);

L2' represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be increased in the first oblique stretching step end the increase of the clip pitch (in one embodiment, a distance from the inlet of the preheating zone to the outlet of the first oblique stretching zone); and

L3' represents a distance from the inlet of the preheating

zone to the outlet of the second oblique stretching zone.)

[0059]

$$t_3 = (1/a_1) \ln(a_1 \cdot L_3 + b_1) - (1/a_1) \ln(a_1 \cdot L_2 + b_1) + (1/a) \ln(a \cdot L_2 + b) - (1/a) \ln(a \cdot L_1 + b) + L_1/v_1 \quad \text{Equation (4)}$$

Equation (4)

(In the equation, a_1 , b_1 , a , b , v_1 , v_2 , v_3 , L_1 , L_2 , and L_3 are as defined for the equation (2).)

[0060]

$$t_3' = (L_1'/v_1') + (1/a') \ln(a' \cdot L_2' + b') - (1/a') \ln(a' \cdot L_1' + b') + (1/a'') \ln(a'' \cdot L_3' + b'') - (1/a'') \ln(a'' \cdot L_2' + b'') \quad \text{Equation (5)}$$

Equation (5)

(In the equation:

$$a' = (v_1' - v_2') / (L_1' - L_2');$$

$$b' = v_2' - a' \cdot L_2';$$

$$a'' = (v_2' - v_3') / (L_2' - L_3');$$

$$b'' = v_3' - a'' \cdot L_3';$$

v_1' represents the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clips pass the preheating zone;

v_2' represents the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clip pitch of the clips is increased to a predetermined clip pitch (corresponding to the P_2 in the description of the section

C-3) in the first oblique stretching step;

v3' represents the moving speed of the clips having a clip pitch to be increased in the first oblique stretching step when the clip pitch of the clips is reduced to a predetermined clip pitch (corresponding to the **P₄** in the description of the section C-3) in the second oblique stretching step;

L1' represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be increased in the first oblique stretching step start to increase the clip pitch (in one embodiment, a distance from the inlet of the preheating zone to the outlet of the preheating zone);

L2' represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be increased in the first oblique stretching step end the increase of the clip pitch (in one embodiment, a distance from the inlet of the preheating zone to the outlet of the first oblique stretching zone); and

L3' represents a distance from the inlet of the preheating zone to the position at which the clips having a clip pitch to be increased in the first oblique stretching step end the reduction of the clip pitch to a predetermined clip pitch (corresponding to the **P₄** in the description of the section C-3) in the second oblique stretching step (in one embodiment, a distance from the inlet of the preheating zone to the outlet of

the second oblique stretching zone).)

[0061] The second oblique stretching may be typically performed at a temperature T_3 . The temperature T_3 may be equal to the temperature T_2 .

[0062] C-5. Releasing Step

Finally, the clips holding the film are released, whereby the retardation film is obtained. The clips are released after the following has been performed as required: the stretched state of the film is fixed by subjecting the film to heat treatment, and the film is cooled.

[0063] The heat treatment may be typically performed at a temperature T_4 . The temperature T_4 varies depending on the film to be stretched. In some cases, $T_3 \geq T_4$, and in other cases, $T_3 < T_4$. In general, when the film is an amorphous material, $T_3 \geq T_4$, and when the film is a crystalline material, crystallization treatment may be performed by setting the T_3 so that the T_3 may be lower than the T_4 . When $T_3 \geq T_4$, a difference ($T_3 - T_4$) between the temperatures T_3 and T_4 is preferably from 0°C to 50°C . A heat treatment time is typically from 10 seconds to 10 minutes.

[0064] The thermally fixed film is cooled to T_g or less in

ordinary cases. After the clips have been released, portions held by the clips on both ends of the film are cut, and the remainder is taken up.

[0065] D. Pressure-Sensitive Adhesive Layer

The pressure-sensitive adhesive layer is formed of any appropriate pressure-sensitive adhesive. Examples of such pressure-sensitive adhesive include a rubber-based pressure-sensitive adhesive, an acrylic pressure-sensitive adhesive, a silicone-based pressure-sensitive adhesive, a urethane-based pressure-sensitive adhesive, a vinyl alkyl ether-based pressure-sensitive adhesive, a polyvinyl alcohol-based pressure-sensitive adhesive, a polyvinylpyrrolidone-based pressure-sensitive adhesive, a polyacrylamide-based pressure-sensitive adhesive, and a cellulose-based pressure-sensitive adhesive. Of those, an acrylic pressure-sensitive adhesive containing a (meth)acrylic polymer as a base polymer is suitably used. In one embodiment, as described above, the pressure-sensitive adhesive layer contains the dye compound.

[0066] The (meth)acrylic polymer contains, as a monomer unit, an alkyl (meth)acrylate serving as a main component. Examples of the alkyl (meth)acrylate include alkyl (meth)acrylates each having, at its ester end, a linear or branched alkyl group having 1 to 24 carbon atoms. The alkyl

(meth)acrylates may be used alone or in combination thereof. The "alkyl (meth)acrylate" refers to an alkyl acrylate and/or an alkyl methacrylate.

[0067] The alkyl (meth)acrylate having, at its ester end, an alkyl group having 1 to 24 carbon atoms accounts for preferably 40 wt% or more, more preferably 50 wt% or more, still more preferably 60 wt% or more with respect to the total amount of monofunctional monomer components for forming the (meth)acrylic polymer.

[0068] The monomer components may include, as a monofunctional monomer component, a copolymerizable monomer other than the alkyl (meth)acrylate. The copolymerizable monomer may be used as the balance of the monomer components excluding the alkyl (meth)acrylate. For example, a cyclic nitrogen-containing monomer may be incorporated as the copolymerizable monomer. As the cyclic nitrogen-containing monomer, there may be used, without any particular limitation, a monomer that has a polymerizable functional group having an unsaturated double bond, such as a (meth)acryloyl group or a vinyl group, and that has a cyclic nitrogen structure. The cyclic nitrogen structure preferably has a nitrogen atom in a cyclic structure. The content of the cyclic nitrogen-containing monomer is preferably from 0.5 wt% to 50 wt%, more preferably

from 0.5 wt% to 40 wt%, still more preferably from 0.5 wt% to 30 wt% with respect to the total amount of the monofunctional monomer components for forming the (meth)acrylic polymer.

[0069] The monomer components for forming the (meth)acrylic polymer may include any other functional group-containing monomer as required. Examples of such monomer include a carboxyl group-containing monomer, a monomer having a cyclic ether group, and a hydroxyl group-containing monomer.

[0070] As the (meth)acrylic polymer, there is generally used a (meth)acrylic polymer having a weight-average molecular weight in the range of from 500,000 to 3,000,000. In consideration of durability, in particular, heat resistance, a (meth)acrylic polymer having a weight-average molecular weight of from 700,000 to 2,700,000 is preferably used. The weight-average molecular weight is more preferably from 800,000 to 2,500,000. A weight-average molecular weight of less than 500,000 is not preferred in terms of heat resistance. In addition, a weight-average molecular weight of more than 3,000,000 is not preferred because such (meth)acrylic polymer requires a large amount of a diluting solvent in order to be adjusted to an appropriate viscosity when applied, leading to an increase in cost. The weight-average molecular weight refers to a value measured by gel permeation chromatography (GPC) and

calculated in terms of polystyrene.

[0071] Any appropriate method may be adopted as a method of producing the (meth)acrylic polymer, and examples thereof include various kinds of radical polymerization including: solution polymerization; radiation polymerization, such as ultraviolet (UV) polymerization; bulk polymerization; and emulsion polymerization. In addition, the (meth)acrylic polymer to be obtained may be any of a random copolymer, a block copolymer, a graft copolymer, and the like.

[0072] E. Polarizer

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

[0073] Specific examples of the polarizer formed of 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.

[0074] 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.

[0075] A specific example of the polarizer obtained by using a 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, the stretching typically includes stretching of 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. 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 of such method of producing the polarizer are described in, for example, JP 2012-73580 A, the description of which is incorporated herein by reference in its entirety.

[0076] The thickness of the polarizer is, for example, from 1 μm to 80 μm . In one embodiment, the thickness of the polarizer is preferably from 1 μm to 25 μm , more preferably from 3 μm to 10 μm , particularly preferably from 3 μm to 8 μm . When the thickness of the polarizer falls within such ranges, curling at the time of heating can be satisfactorily suppressed, and satisfactory appearance durability at the time of heating is obtained.

[0077] 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 35.0% to 46.0%, preferably from 37.0% 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.

[0078] F. Protective Layer

The protective layer is formed of any appropriate film that may be used as a protective film for protecting the polarizer. As a material serving as a main component of the protective film, there are specifically given, for example, cellulose-based resins, such as triacetylcellulose (TAC), and transparent resins, such as polyester-based, polyvinyl alcohol-based, polycarbonate-based, polyamide-based, polyimide-based, polyether sulfone-based, polysulfone-based, polystyrene-based,

polynorbornene-based, polyolefin-based, (meth)acrylic, and acetate-based resins. There are also given, for example, thermosetting resins or UV-curable resins, such as (meth)acrylic, urethane-based, (meth)acrylic urethane-based, epoxy-based, and silicone-based resins. There are also given, for example, glassy polymers, 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 a 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.

[0079] The thickness of the protective film is preferably from 10 μm to 100 μm . The protective film may be laminated on the polarizer via an adhesion layer (specifically an adhesive layer or a pressure-sensitive adhesive layer), or may be laminated so as to be brought into close contact with the polarizer (without via the adhesion layer). As required, the protective film to be arranged at the outermost surface of the

circularly polarizing plate may have formed thereon a surface treated layer, such as a hard coat layer, an antiglare layer, and an antireflection layer.

[0080] G. Image Display Apparatus

The circularly polarizing plate described in the sections A to F may be used for an image display apparatus. Therefore, the present invention also encompasses an image display apparatus using such optical laminate. Typical examples of the image display apparatus include a liquid crystal display apparatus and an organic EL display apparatus. The image display apparatus according to an embodiment of the present invention includes the circularly polarizing plate described in the sections A to F.

Examples

[0081] Now, the present invention is specifically described by way of Examples. However, the present invention is not limited by Examples below. Measurement and evaluation methods for characteristics are as described below.

(1) Thickness

Measurement was performed with a digital gauge (manufactured by Ozaki MFG. Co., Ltd., product name: "DG-205 type pds-2").

(2) In-plane Retardation

Retardation films used in Examples and Comparative Examples were each measured for its in-plane retardations with AxoScan (manufactured by Axometrics, Inc.). A measurement temperature was set to 23°C, and measurement wavelengths were set to 450 nm and 550 nm.

(3) Reflectance and Reflection Hue

Organic EL panels obtained in Examples and Comparative Examples were each caused to display a black image, and the front reflectance and reflection hue thereof were measured with a spectrophotometer CM-2600d manufactured by Konica Minolta, Inc.

In addition, for the reflection hue $u'v'$ obtained by the measurement, a distance from a neutral point ($(u',v')=(0.210,0.471)$) on a chromaticity diagram was calculated, and the resultant value was adopted as $\Delta u'v'$.

(4) Brightness

The organic EL panels obtained in Examples and Comparative Examples were each caused to display a white image, and the front brightness thereof was measured with a spectroradiometer manufactured by Topcon Technohouse Corporation (product name: "SR-UL1R").

(5) Bending Resistance

Circularly polarizing plates obtained in Examples and Comparative Examples were each cut into a size of 150 mm long by 20 mm wide to serve as an evaluation sample.

The evaluation sample was hung and suspended over a horizontally placed mandrel having a diameter of 12 mm, with its protective film facing outward, under a state in which a metal ball having a diameter of 1 mm was interposed between the evaluation sample and the mandrel. Then, a state in which loads were applied to both ends of the evaluation sample at a total of 300 g was kept for 10 seconds. After that, the bending resistance of the circularly polarizing plate was evaluated by the following criteria.

- ...No abnormality was found in the circularly polarizing plate.
- ×...A crack occurred in the protective film.

[0082] [Example 1]

1. Production of Polarizing Plate

An elongate roll of a polyvinyl alcohol film having a thickness of 60 μm (manufactured by Kuraray Co., Ltd., product name: "PE6000") was uniaxially stretched in its elongate direction with a roll stretching machine at a ratio of 5.9 times in the elongate direction, and at the same time, was subjected

to swelling, dyeing, cross-linking, and washing treatments, followed finally by drying treatment. Thus, a polarizer having a thickness of 22 μm was produced.

Specifically, in the swelling treatment, the film was stretched at a ratio of 2.2 times while being treated with pure water at 20°C. Then, in the dyeing treatment, the film was stretched at a ratio of 1.4 times while being treated in an aqueous solution at 30°C containing iodine and potassium iodide at a weight ratio of 1:7, the aqueous solution having an iodine concentration adjusted so that the polarizing film to be produced had a transmittance of 43.0%. Further, two-stage cross-linking treatment was adopted for the cross-linking treatment. In the first-stage cross-linking treatment, the film was stretched at a ratio of 1.2 times while being treated in an aqueous solution at 40°C having dissolved therein boric acid and potassium iodide. The boric acid content and potassium iodide content of the aqueous solution of the first-stage cross-linking treatment were set to 5.0 wt% and 3.0 wt%, respectively. In the second-stage cross-linking treatment, the film was stretched at a ratio of 1.6 times while being treated in an aqueous solution at 65°C having dissolved therein boric acid and potassium iodide. The boric acid content and potassium iodide content of the aqueous solution of the second-stage cross-linking treatment were set to 4.3 wt% and 5.0 wt%, respectively. In addition, in the washing

treatment, the film was treated in a potassium iodide aqueous solution at 20°C. The potassium iodide content of the aqueous solution of the washing treatment was set to 2.6 wt%. Finally, in the drying treatment, the film was dried at 70°C for 5 minutes. Thus, the polarizer was obtained.

A low-reflection TAC film (thickness: 72 μm , manufactured by Dai Nippon Printing Co., Ltd., product name: "DSG-03HL"), which was a TAC film having a hard coat (HC) layer formed by low-reflection hard coat treatment on one surface thereof, was bonded to one surface of the obtained polarizer via a polyvinyl alcohol-based adhesive to provide an elongate polarizing plate having a configuration "protective film/polarizer".

2. Preparation of Pressure-sensitive Adhesive

A reaction vessel with a condenser, a nitrogen inlet tube, a temperature gauge, and a stirring device was loaded with 94.9 parts of butyl acrylate, 5 parts of acrylic acid, 0.1 part of 2-hydroxyethyl acrylate, and dibenzoyl peroxide in an amount of 0.3 part with respect to 100 parts of the monomers (solid content) together with ethyl acetate. Under a nitrogen gas stream, the mixture was subjected to a reaction at 60°C for 7 hours, and then ethyl acetate was added to the reaction liquid to provide a solution containing an acrylic polymer having a weight-average molecular weight of 2,200,000 (solid content

concentration: 30 wt%). Per 100 parts of the solid content of the acrylic polymer solution, 0.6 part of trimethylolpropane tolylene diisocyanate (manufactured by Nippon Polyurethane Industry Co., Ltd., product name: "Coronate L"), 0.075 part of γ -glycidoxypropylmethoxysilane (manufactured by Shin-Etsu Chemical Co., Ltd., product name: "KBM-403"), and 1 part by weight of FDR-003 (manufactured by Yamada Chemical Co., Ltd., maximum absorption wavelength in absorption spectrum: 702 nm, absorption half-width: 100 nm) serving as a dye compound were blended, and the whole was stirred to provide a dye compound-containing pressure-sensitive adhesive.

The dye compound-containing pressure-sensitive adhesive was applied to a separator formed of a polyester film that had been subjected to surface treatment with a silicone-based releasing agent, and was subjected to heating treatment at 155°C for 3 minutes to provide a pressure-sensitive adhesive layer having a thickness of 20 μm .

3. Production of Retardation Film

81.98 Parts by mass of isosorbide, 47.19 parts by mass of tricyclodecanedimethanol, 175.1 parts by mass of diphenyl carbonate, and 0.979 part by mass of a 0.2 mass% aqueous solution of cesium carbonate serving as a catalyst were loaded into a reaction vessel. Under a nitrogen atmosphere, as a first step

of a reaction, a heating bath temperature was increased to 150°C and the raw materials were dissolved while being stirred as required (about 15 minutes).

Next, pressure was changed from normal pressure to 13.3 kPa, and while the heating bath temperature was increased to 190°C in 1 hour, generated phenol was taken out of the reaction vessel. The entire reaction vessel was kept at 190°C for 15 minutes. After that, as a second step, the pressure in the reaction vessel was set to 6.67 kPa, the heating bath temperature was increased to 230°C in 15 minutes, and generated phenol was taken out of the reaction vessel. As the stirring torque of the stirrer increased, the temperature was increased to 250°C in 8 minutes, and in order to remove generated phenol, the pressure in the reaction vessel was caused to reach 0.200 kPa or less. After predetermined stirring torque had been reached, the reaction was terminated, and the reaction product was extruded into water to provide pellets of a polycarbonate copolymer.

The polycarbonate resin was formed into a polycarbonate resin film having a thickness of 60 μm with a film-forming apparatus including a single-screw extruder (manufactured by Toshiba Machine Co., Ltd., screw diameter: 25 mm, cylinder present temperature: 220°C), a T-die (width: 300 mm, preset temperature: 220°C), a chill roll (preset temperature: 120°C to

130°C), and a take-up unit.

The polycarbonate resin film was obliquely stretched with the stretching apparatus illustrated in FIG. 2 to provide a retardation film. A preheating temperature and a stretching temperature were set to 140.5°C, and the oblique stretching ratio represented by the equation (1) was set to 3.0 times. A stretching direction was set to 45° with respect to the lengthwise direction of the film. Then, in the releasing zone, the film was thermally fixed by being held at 125°C for 60 seconds. The thermally fixed film was cooled to 100°C, and then the left and right clips were released. The obtained retardation film had a thickness of 20 μm , an $\text{Re}(550)$ of 125 nm, and a ratio " $\text{Re}(450)/\text{Re}(550)$ " of 1.02.

4. Production of Circularly Polarizing Plate and Organic EL Panel

An easy-adhesive composition prepared using a modified polyolefin resin and a PVA-based resin was applied to one surface of the retardation film and dried to form an easy-adhesion layer (thickness: 500 nm) on the surface of the retardation film.

The polarizer-side surface of the polarizing plate was bonded to the easy-adhesion layer-formed surface of the retardation film via a water-soluble adhesive containing a PVA-based resin as a main component, to thereby provide a circularly

polarizing plate. The polarizing plate and the retardation film were bonded to each other so that an angle formed between the absorption axis of the polarizer and the slow axis of the retardation film was 45°.

The pressure-sensitive adhesive layer was bonded to the retardation film-side surface of the circularly polarizing plate. Next, the circularly polarizing plate was bonded to the viewer side of the organic EL panel of an organic EL display apparatus (manufactured by LG Display Co., Ltd., product name: "55C7P") via the pressure-sensitive adhesive layer to provide an organic EL panel of Example 1.

The obtained circularly polarizing plate was subjected to the evaluation (5). In addition, the obtained organic EL panel was subjected to the evaluations (3) and (4). The results are shown in Table 1.

[0083] [Example 2]

A norbornene-based resin film (manufactured by Zeon Corporation, product name: "ZF-14") was subjected to free-end longitudinal uniaxial stretching with Lab Stretcher (manufactured by Bruckner, KARO IV) at a stretching temperature of 137°C and a stretching ratio of 2.0 times to provide a retardation film.

The obtained retardation film had a thickness of 20 μm , an in-plane retardation $\text{Re}(550)$ of 125 nm, and a ratio " $\text{Re}(450)/\text{Re}(550)$ " of 1.01.

A circularly polarizing plate and an organic EL panel were produced in the same manner as in Example 1 except that this retardation film was used. The obtained circularly polarizing plate and organic EL panel were subjected to the same evaluations as those of Example 1. The results are shown in Table 1.

[0084] [Example 3]

A retardation film was obtained in the same manner as in Example 1 except that the polycarbonate resin film having a thickness of 60 μm was stretched with the preheating temperature and the stretching temperature being set to 140°C. The obtained retardation film had a thickness of 20 μm , an $\text{Re}(550)$ of 130 nm, and a ratio " $\text{Re}(450)/\text{Re}(550)$ " of 1.02.

In addition, a pressure-sensitive adhesive layer was obtained in the same manner as in Example 1 except that 0.5 part by weight of FDR-004 (manufactured by Yamada Chemical Co., Ltd., maximum absorption wavelength in absorption spectrum: 712 nm, absorption half-width: 36 nm) was blended as the dye compound.

A circularly polarizing plate and an organic EL panel were produced in the same manner as in Example 1 except that the obtained retardation film and pressure-sensitive adhesive layer were used. The obtained circularly polarizing plate and organic EL panel were subjected to the same evaluations as those of Example 1. The results are shown in Table 1.

[0085] [Example 4]

A retardation film was obtained in the same manner as in Example 1 except that the polycarbonate resin film having a thickness of 75 μm was stretched with the preheating temperature and the stretching temperature being set to 144.5°C. The obtained retardation film had a thickness of 25 μm , an $\text{Re}(550)$ of 125 nm, and a ratio " $\text{Re}(450)/\text{Re}(550)$ " of 1.02.

A circularly polarizing plate and an organic EL panel were produced in the same manner as in Example 1 except that the obtained retardation film was used. The obtained circularly polarizing plate and organic EL panel were subjected to the same evaluations as those of Example 1. The results are shown in Table 1.

[0086] [Example 5]

A retardation film was obtained in the same manner as in Example 1 except that the polycarbonate resin film having a

thickness of 60 μm was stretched with the preheating temperature and the stretching temperature being set to 141.2°C. The obtained retardation film had a thickness of 20 μm , an $\text{Re}(550)$ of 120 nm, and a ratio " $\text{Re}(450)/\text{Re}(550)$ " of 1.02.

A circularly polarizing plate and an organic EL panel were produced in the same manner as in Example 1 except that the obtained retardation film was used. The obtained circularly polarizing plate and organic EL panel were subjected to the same evaluations as those of Example 1. The results are shown in Table 1.

[0087] [Comparative Example 1]

Polymerization was performed with a batch polymerization apparatus formed of two vertical reactors each including a stirring blade and a reflux condenser controlled to 100°C. 29.60 Parts by mass (0.046 mol) of bis[9-(2-phenoxy-carbonyl-ethyl)fluoren-9-yl]methane (Compound 3), 29.21 parts by mass (0.200 mol) of ISB, 42.28 parts by mass (0.139 mol) of SPG, 63.77 parts by mass (0.298 mol) of DPC, and 1.19×10^{-2} part by mass (6.78×10^{-5} mol) of calcium acetate monohydrate serving as a catalyst were loaded. After a first reactor had been purged with nitrogen under reduced pressure, the inside of the reactor was warmed with a heating medium, and when a temperature in the reactor reached 100°C, stirring was started.

40 Minutes after the start of the temperature increase, the temperature in the reactor was caused to reach 220°C and the reactor was controlled so as to hold the temperature, and at the same time, a pressure reduction was started. 90 Minutes after the temperature had reached 220°C, a pressure in the reactor was set to 13.3 kPa. A phenol vapor produced as a by-product of the polymerization reaction was introduced into the reflux condenser at 100°C, a monomer component present in a slight amount in the phenol vapor was returned to the reactor, and a phenol vapor that did not condense was introduced into a condenser at 45°C and recovered. Nitrogen was introduced into the first reactor to return the pressure to the atmospheric pressure once. After that, an oligomerized reaction liquid in the first reactor was transferred to a second reactor. Next, the increase of a temperature in the second reactor and the reduction of a pressure therein were started, and the temperature in the reactor and the pressure therein were set to 240°C and 0.2 kPa, respectively in 50 minutes. After that, the polymerization was caused to proceed until predetermined stirring power was achieved. When the predetermined power was achieved, nitrogen was introduced into the reactor to return the pressure to the atmospheric pressure. The produced polyester carbonate was extruded into water, and the strand was cut to provide pellets.

The resultant polycarbonate resin was dried in a vacuum at

80°C for 5 hours, and was then formed into a resin film having a thickness of 135 μm with a film-forming apparatus including a single screw extruder (manufactured by Toshiba Machine Co., Ltd., cylinder preset temperature: 250°C), a T-die (width: 300 mm, preset temperature: 250°C), a chill roll (preset temperature: 120°C to 130°C), and a take-up unit.

The polycarbonate resin film was obliquely stretched with the stretching apparatus illustrated in FIG. 2 to provide a retardation film. A preheating temperature was set to 145°C, and a stretching temperature was set to 138°C. The oblique stretching ratio represented by the equation (1) was set to 2.94 times. A stretching direction was set to 45° with respect to the lengthwise direction of the film. Next, in the releasing zone, the film was thermally fixed by being held at 125°C for 60 seconds. The thermally fixed film was cooled to 100°C, and then the left and right clips were released. The obtained retardation film had a thickness of 58 μm , an $\text{Re}(550)$ of 144 nm, and a ratio " $\text{Re}(450)/\text{Re}(550)$ " of 0.855.

In addition, a pressure-sensitive adhesive layer was obtained in the same manner as in Example 1 except that no dye compound was blended into the pressure-sensitive adhesive composition.

A circularly polarizing plate and an organic EL panel were produced in the same manner as in Example 1 except that the obtained retardation film and pressure-sensitive adhesive layer were used. The obtained circularly polarizing plate and organic EL panel were subjected to the same evaluations as those of Example 1. The results are shown in Table 1.

[0088] [Comparative Example 2]

A pressure-sensitive adhesive layer was obtained in the same manner as in Example 1 except that no dye compound was blended into the pressure-sensitive adhesive composition.

A circularly polarizing plate and an organic EL panel were produced in the same manner as in Example 1 except that the obtained pressure-sensitive adhesive layer was used. The obtained circularly polarizing plate and organic EL panel were subjected to the same evaluations as those of Example 1. The results are shown in Table 1.

[0089] [Comparative Example 3]

A pressure-sensitive adhesive layer was obtained in the same manner as in Example 1 except that 0.3 part by weight of FDG-007 (manufactured by Yamada Chemical Co., Ltd., maximum absorption wavelength in absorption spectrum: 592 nm, absorption half-width: 29 nm) was blended as the dye compound.

A circularly polarizing plate and an organic EL panel were produced in the same manner as in Example 1 except that the obtained pressure-sensitive adhesive layer was used. The obtained circularly polarizing plate and organic EL panel were subjected to the same evaluations as those of Example 1. The results are shown in Table 1.

[0090]

Table 1

	Dye compound			Retardation film			Bending resistance			Reflection hue			White bright ness (Cd)
	Blending amount (part (s) by weight)	Maximum absorption wavelength (nm)	Absorption half-width (nm)	Re (450) / Re (550)	Re (550) (nm)	Thickness (μm)				u'	v'	Δu'v'	
Example 1	1	702	100	1.02	125	20	o			0.219	0.459	0.015	143
Example 2	1	702	100	1.01	125	20	o			0.221	0.459	0.017	144
Example 3	0.5	712	36	1.02	130	20	o			0.223	0.448	0.027	142
Example 4	1	702	100	1.02	125	25	o			0.220	0.460	0.016	142
Example 5	1	702	100	1.02	120	20	o			0.221	0.473	0.011	142
Comparative Example 1	0	—	—	0.855	144	58	x			0.211	0.462	0.009	153
Comparative Example 2	0	—	—	1.02	125	20	o			0.249	0.460	0.042	163
Comparative Example 3	0.3	592	29	1.02	125	20	o			0.242	0.408	0.071	121

[0091] The circularly polarizing plates of Comparative Examples each had low bending resistance or caused undesired coloring in the reflection hue. In contrast, the circularly polarizing plates of Examples were each excellent in bending resistance, and each had a reflection hue close to a neutral one. In addition, the circularly polarizing plates of Examples were each able to achieve the above-mentioned excellent characteristics without significantly reducing the white brightness of the organic EL panel as compared to the circularly polarizing plates of Comparative Examples 1 and 2 containing no dye compound.

Industrial Applicability

[0092] The circularly polarizing plate of the present invention can be suitably used for an image display apparatus, such as an organic EL display apparatus.

Reference Signs List

- [0093] **10** polarizer
- 20** retardation layer
- 30** pressure-sensitive adhesive layer
- 100** circularly polarizing plate

Claims

[Claim 1] A circularly polarizing plate, comprising:

a polarizer;

a retardation layer; and

a pressure-sensitive adhesive layer,

wherein an angle formed between an absorption axis of the polarizer and a slow axis of the retardation layer is from 39° to 51° ,

wherein at least any one of the polarizer, the retardation layer, or the pressure-sensitive adhesive layer contains a dye compound having, in an absorption spectrum thereof, a maximum absorption wavelength in a wavelength region of 650 nm or more, and

wherein in-plane retardations of the retardation layer satisfy $Re(450)/Re(550) > 1$,

where $Re(450)$ represents an in-plane retardation measured at 23°C with light having a wavelength of 450 nm, and $Re(550)$ represents an in-plane retardation measured at 23°C with light having a wavelength of 550 nm.

[Claim 2] The circularly polarizing plate according to claim 1, wherein the in-plane retardations of the retardation layer satisfy $1.1 > Re(450)/Re(550) > 1$.

[Claim 3] The circularly polarizing plate according to claim 1

or 2, wherein an in-plane retardation of the retardation layer satisfies $115\text{ nm} \leq \text{Re}(550) \leq 135\text{ nm}$,

where $\text{Re}(550)$ represents an in-plane retardation measured at 23°C with light having a wavelength of 550 nm.

[Claim 4] The circularly polarizing plate according to any one of claims 1 to 3, wherein the pressure-sensitive adhesive layer contains the dye compound.

[Claim 5] The circularly polarizing plate according to any one of claims 1 to 4, wherein the retardation layer is formed of a retardation film having an alicyclic structure.

[Claim 6] An image display apparatus, comprising the circularly polarizing plate of at least any one of claims 1 to 5.