

Description

Title of Invention: ADHESIVE FILM, FOLDABLE DEVICE, AND ROLLABLE DEVICE

Technical Field

[0001]

The present invention relates to a pressure-sensitive adhesive film. The present invention also relates to a foldable device including such pressure-sensitive adhesive film, and a rollable device including such pressure-sensitive adhesive film.

Background Art

[0002]

A pressure-sensitive adhesive film has been used in the reinforcement, surface protection, and the like of members of various shapes.

[0003]

For example, when an integrated circuit (IC) or a flexible printed circuit board (FPC) is joined to the substrate (e.g., TFT substrate) of a semiconductor element, thermocompression bonding is typically performed with an anisotropic conductive film (ACF). At the time of the performance of such thermocompression bonding, the pressure-sensitive adhesive film may be bonded to the back side of the substrate of the

semiconductor element in advance to reinforce the element (e.g., Patent Literature 1).

[0004]

In addition, a method of producing a flexible device or a rollable device whose development has started to advance in recent years generally includes: forming a peeling layer and a flexible or rollable film substrate on a supporting substrate, such as glass; forming a TFT substrate on the film substrate; further forming an organic EL layer on the TFT substrate; and then peeling the supporting substrate to produce the flexible device or the rollable device. However, a flexible display layer or a rollable display layer is so thin that an inconvenience occurs in the device owing to its handling or the like. Accordingly, the pressure-sensitive adhesive film may be bonded to the back side of the film substrate to reinforce such device (e.g., Patent Literature 2).

[0005]

The substrate of the semiconductor element, or the flexible device or the rollable device may be repeatedly bent. Accordingly, when the bending characteristic of the pressure-sensitive adhesive film bonded to the back side of the substrate is poor, the recoverability of such substrate or device after the bending may deteriorate, and in the worst case, the substrate

or the device may be ruptured by the repeated bending. Specifically, when an attempt is made to bond the pressure-sensitive adhesive film to a bending portion (e.g., a movable bending portion of a foldable member), for example, such problems as described below occur.

[0006]

When the pressure-sensitive adhesive film is bent with an angle, a compressing force acts on the radially inner side of the bent film, and hence the deformation of the pressure-sensitive adhesive film itself occurs so as to relax the force. Specifically, for example, a wrinkle is liable to occur in the film.

[0007]

When the pressure-sensitive adhesive film is bent with an angle, a stress by which the film is tensioned acts on the radially outer side of the bent film. Accordingly, the floating of the film from an adherend occurs at the time of the relaxation of the stress.

[0008]

When the pressure-sensitive adhesive film is bent with an angle, the thickness of a site of the pressure-sensitive adhesive film to be bent or a site thereof to be tensioned largely changes.

Also under such state, a wrinkle is liable to occur in the film, or the floating of the film occurs. For example, when the pressure-sensitive adhesive film is tensioned, the thickness of the pressure-sensitive adhesive film remarkably reduces, and hence its floating from an adherend is liable to occur.

[0009]

As described above, in the related-art pressure-sensitive adhesive film, unevenness following to a corner portion or a bending portion cannot be sufficiently achieved yet.

[0010]

In particular, when the pressure-sensitive adhesive film is bonded to a movable bending portion, bending is repeated, and hence a state in which a bending mark (so-called "curl") is left in the pressure-sensitive adhesive film on the movable bending portion is established.

[0011]

In addition, when the integrated circuit (IC) or the flexible printed circuit board (FPC) is joined to the substrate (e.g., TFT substrate) of the semiconductor element by performing thermocompression bonding, the bonding is performed after the position at which the IC or the FPC and the substrate are joined to each other has been observed from the back side of the

substrate. Accordingly, the pressure-sensitive adhesive film to be bonded to the back side of the substrate is required to have transparency.

Citation List

Patent Literature

[0012]

[PTL 1] JP 5600039 B2

[PTL 2] JP 6376271 B1

Summary of Invention

Technical Problem

[0013]

An object of the present invention is to provide a pressure-sensitive adhesive film excellent in bendability and transparency. Another object of the present invention is to provide a foldable device and a rollable device each of which is excellent in bendability.

Solution to Problem

[0014]

According to one embodiment of the present invention, there is provided a pressure-sensitive adhesive film, including: a base material layer; and a pressure-sensitive adhesive layer, wherein the pressure-sensitive adhesive film has a $\tan\delta(0.7\%)$ at

a strain of 0.7% of 0.1 or less, which is measured in a tension mode of a viscoelasticity-measuring apparatus.

[0015]

According to one embodiment of the present invention, there is provided a pressure-sensitive adhesive film, including: a base material layer; and a pressure-sensitive adhesive layer, wherein a difference ($\tan\delta(0.7\%) - \tan\delta(0.1\%)$) between a $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film at a strain of 0.7% and a $\tan\delta(0.1\%)$ thereof at a strain of 0.1%, which are measured in a tension mode of a viscoelasticity-measuring apparatus, is 0.05 or less.

[0016]

In one embodiment, the pressure-sensitive adhesive film of the present invention has a bending angle of from 60° to 180° after the pressure-sensitive adhesive film has been bent at a diameter of 6 mmφ and held at 90°C for 48 hours, and then the bending has been released, and the pressure-sensitive adhesive film has been left to stand at 23°C and 50%RH for 24 hours.

[0017]

In one embodiment, the pressure-sensitive adhesive film of the present invention further includes a top coat layer on a surface of the base material layer opposite to a surface thereof

having the pressure-sensitive adhesive layer.

[0018]

In one embodiment, the top coat layer contains a binder containing at least one kind selected from a polyester resin and a urethane-based resin.

[0019]

In one embodiment, the binder contains the urethane-based resin.

[0020]

In one embodiment, the top coat layer contains an antistatic component.

[0021]

In one embodiment, the base material layer has a Young's modulus of 6.0×10^7 Pa or more at 23°C.

[0022]

In one embodiment, a material for the base material layer is at least one kind selected from polyimide and polyether ether ketone.

[0023]

In one embodiment, the pressure-sensitive adhesive film of the present invention further includes a top coat layer on a surface of the base material layer opposite to a surface thereof having the pressure-sensitive adhesive layer, wherein the top coat layer contains a binder containing a urethane-based resin and an antistatic component, and wherein a material for the base material layer is at least one kind selected from polyimide and polyether ether ketone.

[0024]

In one embodiment, the pressure-sensitive adhesive film of the present invention has a total light transmittance of 20% or more.

[0025]

In one embodiment, the pressure-sensitive adhesive film of the present invention has a haze of 15% or less.

[0026]

In one embodiment, the pressure-sensitive adhesive layer has a pressure-sensitive adhesive strength to a SUS plate of 1 N/25 mm or more at 23°C, a tensile rate of 300 mm/min, and a peel angle of 180°.

[0027]

In one embodiment, the pressure-sensitive adhesive layer contains an acrylic pressure-sensitive adhesive.

[0028]

In one embodiment, the pressure-sensitive adhesive film of the present invention is bonded to a foldable member.

[0029]

In one embodiment, the foldable member is an OLED.

[0030]

In one embodiment, the pressure-sensitive adhesive film of the present invention is bonded to a rollable member.

[0031]

In one embodiment, the rollable member is an OLED.

[0032]

According to one embodiment of the present invention, there is provided a foldable device, including the above-mentioned pressure-sensitive adhesive film.

[0033]

According to one embodiment of the present invention, there is provided a rollable device, including the above-mentioned

pressure-sensitive adhesive film.

Advantageous Effects of Invention

[0034]

According to the present invention, the pressure-sensitive adhesive film excellent in bendability and transparency can be provided. According to the present invention, the foldable device and the rollable device each of which is excellent in bendability can also be provided.

Brief Description of Drawings

[0035]

FIG. 1 is a schematic sectional view for illustrating a foldable device according to one embodiment of the present invention, and is an illustration of one usage form of a pressure-sensitive adhesive film of the present invention.

FIG. 2 is a schematic sectional view for illustrating a method of evaluating bending recoverability.

FIG 3 is a schematic sectional view for illustrating a method for a peeling evaluation.

Description of Embodiments

[0036]

<<<<Pressure-sensitive Adhesive Film>>>>

A pressure-sensitive adhesive film of the present

invention includes a base material layer and a pressure-sensitive adhesive layer. That is, the pressure-sensitive adhesive film of the present invention may include any appropriate other layer to such an extent that the effects of the present invention are not impaired as long as the pressure-sensitive adhesive film includes the base material layer and the pressure-sensitive adhesive layer.

[0037]

The number of the base material layers may be one, or may be two or more. The number of the base material layers is preferably one because the effects of the present invention can be further expressed.

[0038]

The number of the pressure-sensitive adhesive layers may be one, or may be two or more. The number of the pressure-sensitive adhesive layers is preferably one because the effects of the present invention can be further expressed.

[0039]

Any appropriate release liner may be arranged on the surface of the pressure-sensitive adhesive layer opposite to the base material layer for, for example, protecting the pressure-sensitive adhesive film of the present invention until its use.

[0040]

Examples of the release liner include: a release liner obtained by subjecting the surface of a base material (liner base material), such as paper or a plastic film, to a silicone treatment; and a release liner obtained by laminating a polyolefin-based resin on the surface of a base material (liner base material), such as paper or a plastic film. Examples of the plastic film serving as the liner base material include a polyethylene film, a polypropylene film, a polybutene film, a polybutadiene film, a polymethylpentene film, a polyvinyl chloride film, a vinyl chloride copolymer film, a polyethylene terephthalate film, a polybutylene terephthalate film, a polyurethane film, and an ethylene-vinyl acetate copolymer film.

[0041]

The thickness of the release liner is preferably from 1 μm to 500 μm , more preferably from 3 μm to 450 μm , still more preferably from 5 μm to 400 μm , particularly preferably from 10 μm to 300 μm .

[0042]

The total thickness "d" of the pressure-sensitive adhesive film of the present invention is preferably from 1 μm to 500 μm , more preferably from 5 μm to 200 μm , still more preferably from

10 μm to 150 μm , particularly preferably from 20 μm to 100 μm , most preferably from 30 μm to 80 μm . When the total thickness "d" of the pressure-sensitive adhesive film of the present invention falls within the ranges, the effects of the present invention can be further expressed.

[0043]

The $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film of the present invention at a strain of 0.7% measured in the tension mode of a viscoelasticity-measuring apparatus is 0.1 or less, preferably 0.09 or less, more preferably 0.08 or less, still more preferably 0.07 or less, particularly preferably 0.06 or less. When the $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film of the present invention at a strain of 0.7% measured in the tension mode of the viscoelasticity-measuring apparatus falls within the ranges, the effects of the present invention can be further expressed.

[0044]

The $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film at a strain of 0.7% measured in the tension mode of the viscoelasticity-measuring apparatus is an indicator showing a loss tangent when the pressure-sensitive adhesive film is bent to a large extent. In the course of the completion of the present invention, the inventors have found, on the basis of

various pieces of experimental data, that when the value falls within the above-mentioned ranges, the effects of the present invention can be further expressed. A method of measuring the $\tan\delta(0.7\%)$ at a strain of 0.7% measured in the tension mode of the viscoelasticity-measuring apparatus is described in detail later.

[0045]

The $\tan\delta(0.1\%)$ of the pressure-sensitive adhesive film of the present invention at a strain of 0.1% measured in the tension mode of the viscoelasticity-measuring apparatus is preferably 0.1 or less, more preferably 0.08 or less, still more preferably 0.06 or less, particularly preferably 0.05 or less. When the $\tan\delta(0.1\%)$ of the pressure-sensitive adhesive film of the present invention at a strain of 0.1% measured in the tension mode of the viscoelasticity-measuring apparatus falls within the ranges, the effects of the present invention can be further expressed.

[0046]

The $\tan\delta(0.1\%)$ of the pressure-sensitive adhesive film at a strain of 0.1% measured in the tension mode of the viscoelasticity-measuring apparatus is an indicator showing a loss tangent when the pressure-sensitive adhesive film is bent to a small extent. In the course of the completion of the

present invention, the inventors have found, on the basis of various pieces of experimental data, that when the value falls within the above-mentioned ranges, the effects of the present invention can be further expressed. A method of measuring the $\tan\delta(0.1\%)$ at a strain of 0.1% measured in the tension mode of the viscoelasticity-measuring apparatus is described in detail later.

[0047]

A difference ($\tan\delta(0.7\%) - \tan\delta(0.1\%)$) between the $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film of the present invention at a strain of 0.7% and the $\tan\delta(0.1\%)$ thereof at a strain of 0.1%, which are measured in the tension mode of the viscoelasticity-measuring apparatus, is preferably 0.05 or less, more preferably 0.04 or less, still more preferably 0.03 or less. When the difference ($\tan\delta(0.7\%) - \tan\delta(0.1\%)$) between the $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film of the present invention at a strain of 0.7% and the $\tan\delta(0.1\%)$ thereof at a strain of 0.1%, which are measured in the tension mode of the viscoelasticity-measuring apparatus, falls within the ranges, the effects of the present invention can be further expressed.

[0048]

The difference ($\tan\delta(0.7\%) - \tan\delta(0.1\%)$) between the $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film at a strain

of 0.7% and the $\tan\delta(0.1\%)$ thereof at a strain of 0.1%, which are measured in the tension mode of the viscoelasticity-measuring apparatus, is an indicator showing a difference between the loss tangent when the pressure-sensitive adhesive film is bent to a large extent and the loss tangent when the pressure-sensitive adhesive film is bent to a small extent. In the course of the completion of the present invention, the inventors have found, on the basis of various pieces of experimental data, that when the value falls within the above-mentioned ranges, the effects of the present invention can be further expressed.

[0049]

A bending angle after the pressure-sensitive adhesive film of the present invention has been bent at a diameter of 6 mm ϕ and held at 90°C for 48 hours, and then the bending has been released, and the pressure-sensitive adhesive film has been left to stand at 23°C and 50%RH for 24 hours is preferably from 60° to 180°, more preferably from 80° to 180°, still more preferably from 100° to 180°, particularly preferably from 120° to 180°, most preferably from 150° to 180°. When the bending angle after the pressure-sensitive adhesive film of the present invention has been bent at a diameter of 6 mm ϕ and held at 90°C for 48 hours, and then the bending has been released, and the pressure-sensitive adhesive film has been left to stand at 23°C and 50%RH

for 24 hours falls within the ranges, the effects of the present invention can be further expressed.

[0050]

The bending angle after the pressure-sensitive adhesive film has been bent at a diameter of 6 mmφ and held at 90°C for 48 hours, and then the bending has been released, and the pressure-sensitive adhesive film has been left to stand at 23°C and 50%RH for 24 hours is an indicator showing recoverability after the bending. A method of measuring the bending angle after the pressure-sensitive adhesive film has been bent at a diameter of 6 mmφ and held at 90°C for 48 hours, and then the bending has been released, and the pressure-sensitive adhesive film has been left to stand at 23°C and 50%RH for 24 hours is described in detail later.

[0051]

The total light transmittance of the pressure-sensitive adhesive film of the present invention is preferably 20% or more, more preferably 30% or more, still more preferably 40% or more, particularly preferably 50% or more, most preferably 60% or more. When the total light transmittance of the pressure-sensitive adhesive film of the present invention falls within the ranges, excellent transparency can be further expressed.

[0052]

The haze of the pressure-sensitive adhesive film of the present invention is preferably 15% or less, more preferably 13% or less, still more preferably 10% or less, particularly preferably 8% or less, most preferably 6% or less. When the haze of the pressure-sensitive adhesive film of the present invention falls within the ranges, excellent transparency can be further expressed.

[0053]

The pressure-sensitive adhesive film of the present invention is excellent in bendability and transparency, and is hence preferably bonded to a foldable member. Any appropriate member may be adopted as the foldable member as long as the member can be repeatedly bent. Examples of such foldable member include a foldable optical member and a foldable electronic member, and a typical example thereof is a foldable OLED.

[0054]

The pressure-sensitive adhesive film of the present invention is excellent in bendability and transparency, and is hence preferably bonded to a rollable member. Any appropriate member may be adopted as the rollable member as long as the member can be repeatedly wound and rewound. Examples of such rollable member include a rollable optical member and a rollable

electronic member, and a typical example thereof is a rollable OLED.

[0055]

<<Base Material Layer>>

The thickness of the base material layer is preferably from 1 μm to 500 μm , more preferably from 5 μm to 300 μm , still more preferably from 10 μm to 100 μm , particularly preferably from 15 μm to 80 μm , most preferably from 20 μm to 60 μm . When the thickness of the base material layer falls within the ranges, the effects of the present invention can be further expressed.

[0056]

The Young's modulus of the base material layer at 23°C is preferably 6.0×10^7 Pa or more, more preferably 1.0×10^8 Pa or more, still more preferably 5.0×10^8 Pa or more, particularly preferably 8.0×10^8 Pa or more, most preferably 1.0×10^9 Pa or more. In typical cases, the upper limit of the Young's modulus of the base material layer at 23°C is preferably 1.0×10^{11} Pa or less. When the Young's modulus of the base material layer at 23°C falls within the ranges, the effects of the present invention can be further expressed. When the Young's modulus of the base material layer at 23°C is excessively low, in the case where the pressure-sensitive adhesive film is bent with an angle, there is a risk in that tension on its radially outer side cannot be sufficiently

held with respect to compression on its radially inner side. Accordingly, there is a risk in that the thickness of the pressure-sensitive adhesive film is liable to change, and hence the floating thereof from an adherend is liable to occur. When the Young's modulus of the base material layer at 23°C is excessively high, it may be impossible to easily deform the pressure-sensitive adhesive film. A method of measuring the Young's modulus is described in detail later.

[0057]

Any appropriate material may be adopted as a material for the base material layer to such an extent that the effects of the present invention are not impaired. Such material for the base material layer is typically, for example, a resin material.

[0058]

Examples of the resin material serving as the material for the base material layer include: acrylic resins, such as polyimide (PI), polyether ether ketone (PEEK), polyethylene terephthalate (PET), polyethylene naphthalate (PEN), polybutylene terephthalate (PBT), and polymethyl methacrylate (PMMA); and polycarbonate, triacetyl cellulose (TAC), polysulfone, polyarylate, polyethylene (PE), polypropylene (PP), an ethylene-propylene copolymer, an ethylene-vinyl acetate copolymer (EVA), polyamide (nylon), wholly aromatic polyamide

(aramid), polyvinyl chloride (PVC), polyvinyl acetate, polyphenylene sulfide (PPS), a fluorine-based resin, and a cyclic olefin-based polymer.

[0059]

The resin material serving as the material for the base material layer is preferably, for example, at least one kind selected from polyimide (PI), polyether ether ketone (PEEK), and a cyclic olefin-based polymer, more preferably, for example, at least one kind selected from polyimide (PI) and polyether ether ketone (PEEK) because the effects of the present invention can be further expressed.

[0060]

<<Pressure-sensitive Adhesive Layer>>

The thickness of the pressure-sensitive adhesive layer is preferably from 1 μm to 500 μm , more preferably from 5 μm to 300 μm , still more preferably from 10 μm to 100 μm , particularly preferably from 15 μm to 80 μm , most preferably from 20 μm to 60 μm . When the thickness of the pressure-sensitive adhesive layer falls within the ranges, the effects of the present invention can be further expressed.

[0061]

The pressure-sensitive adhesive strength of the pressure-

sensitive adhesive layer to a glass plate at 23°C, a tensile rate of 300 mm/min, and a peel angle of 180° is preferably 1 N/25 mm or more, more preferably 5 N/25 mm or more, still more preferably 10 N/25 mm or more, particularly preferably 12 N/25 mm or more, most preferably 15 N/25 mm or more. In typical cases, the upper limit of the pressure-sensitive adhesive strength of the pressure-sensitive adhesive layer to the glass plate at 23°C, a tensile rate of 300 mm/min, and a peel angle of 180° is preferably 1,000 N/25 mm or less, more preferably 500 N/25 mm or less, still more preferably 300 N/25 mm or less, particularly preferably 200 N/25 mm or less, most preferably 100 N/25 mm or less. When the pressure-sensitive adhesive strength of the pressure-sensitive adhesive layer to the glass plate at 23°C, a tensile rate of 300 mm/min, and a peel angle of 180° falls within the ranges, the effects of the present invention can be further expressed.

[0062]

The pressure-sensitive adhesive layer contains a base polymer. The base polymers may be used alone or in combination thereof. The content of the base polymer in the pressure-sensitive adhesive layer is preferably from 20 wt% to 100 wt% because the effects of the present invention can be further expressed, and the content is more preferably from 30 wt% to 95 wt%, still more preferably from 40 wt% to 90 wt%, particularly

preferably from 45 wt% to 85 wt%, most preferably from 50 wt% to 80 wt%.

[0063]

Any appropriate polymer may be adopted as the base polymer to such an extent that the effects of the present invention are not impaired. The base polymer is preferably, for example, at least one kind selected from an acrylic polymer, a rubber-based polymer, a silicone-based polymer, and a urethane-based polymer because the effects of the present invention can be further expressed. That is, the pressure-sensitive adhesive layer preferably contains at least one kind selected from an acrylic pressure-sensitive adhesive containing the acrylic polymer, a rubber-based pressure-sensitive adhesive containing the rubber-based polymer, a silicone-based pressure-sensitive adhesive containing the silicone-based polymer, and a urethane-based pressure-sensitive adhesive containing the urethane-based polymer. The pressure-sensitive adhesive layer preferably contains the acrylic pressure-sensitive adhesive because the effects of the present invention can be still further expressed. The acrylic pressure-sensitive adhesive is described in detail below as a typical example of the pressure-sensitive adhesive that may be incorporated into the pressure-sensitive adhesive layer.

[0064]

<Acrylic Pressure-sensitive Adhesive>

The acrylic pressure-sensitive adhesive contains the acrylic polymer as its base polymer. The acrylic pressure-sensitive adhesive may contain a tackifying resin. The acrylic pressure-sensitive adhesive may contain a cross-linking agent.

[0065]

When the acrylic pressure-sensitive adhesive contains the acrylic polymer, the tackifying resin, and the cross-linking agent, the content of the sum total amount of the acrylic polymer, the tackifying resin, and the cross-linking agent with respect to the total amount of the acrylic pressure-sensitive adhesive is preferably 95 wt% or more because the effects of the present invention can be further expressed, and the content is more preferably 97 wt% or more, still more preferably 99 wt% or more.

[0066]

(Acrylic Polymer)

The acrylic polymer is preferably, for example, a polymerized product of monomer components that contain an alkyl (meth)acrylate as a main monomer and that may further contain a sub-monomer having copolymerizability with the main monomer. The term "main monomer" as used herein refers to a component accounting for more than 50 wt% of the entirety of the monomer

components.

[0067]

For example, a compound represented by the following formula (1) may be suitably used as the alkyl (meth)acrylate.



[0068]

Herein, in the formula (1), R^1 represents a hydrogen atom or a methyl group, and R^2 represents a chain-like alkyl group having 1 to 20 carbon atoms (hereinafter, such range of the number of carbon atoms is sometimes represented as "C1-20"). R^2 represents preferably a C1-14 chain-like alkyl group, more preferably a C2-10 chain-like alkyl group, still more preferably a C4-8 chain-like alkyl group from the viewpoint of, for example, the storage modulus of elasticity of the pressure-sensitive adhesive layer. The meaning of the term "chain-like" as used herein comprehends a linear group and a branched group.

[0069]

Examples of the alkyl (meth)acrylate in which R^2 represents a C1-20 chain-like alkyl group include methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate,

s-butyl (meth)acrylate, pentyl (meth)acrylate, isopentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, octyl (meth)acrylate, isooctyl (meth)acrylate, nonyl (meth)acrylate, isononyl (meth)acrylate, decyl (meth)acrylate, isodecyl (meth)acrylate, undecyl (meth)acrylate, lauryl (meth)acrylate, tridecyl (meth)acrylate, tetradecyl (meth)acrylate, pentadecyl (meth)acrylate, hexadecyl (meth)acrylate, heptadecyl (meth)acrylate, octadecyl (meth)acrylate, isostearyl (meth)acrylate, nonadecyl (meth)acrylate, and eicosyl (meth)acrylate. Those alkyl (meth)acrylates may be used alone or in combination thereof.

[0070]

The alkyl (meth)acrylate is preferably, for example, n-butyl acrylate (BA) or 2-ethylhexyl acrylate (2EHA) because the effects of the present invention can be further expressed.

[0071]

The content of the alkyl (meth)acrylate in all the monomer components to be used in the synthesis of the acrylic polymer is preferably 70 wt% or more because the effects of the present invention can be further expressed, and the content is more preferably 85 wt% or more, still more preferably 90 wt% or more. The upper limit of the content of the alkyl (meth)acrylate is preferably 99.5 wt% or less, more preferably 99 wt% or less.

However, the acrylic polymer may be obtained by polymerizing substantially only the alkyl (meth)acrylate.

[0072]

When an alkyl (meth)acrylate in which R^2 represents a C4-8 chain-like alkyl group is used, the ratio of the alkyl (meth)acrylate in which R^2 represents a C4-8 chain-like alkyl group out of the alkyl (meth)acrylates in the monomer components is preferably 50 wt% or more because the effects of the present invention can be further expressed, and the ratio is more preferably 70 wt% or more, still more preferably 90 wt% or more, particularly preferably 95 wt% or more, most preferably from 99 wt% to 100 wt%.

[0073]

An acrylic polymer in which n-butyl acrylate (BA) accounts for 50 wt% or more of all the monomer components is given as one embodiment of the acrylic polymer. In this case, the content of n-butyl acrylate (BA) in all the monomer components is preferably more than 50 wt% and 100 wt% or less because the effects of the present invention can be further expressed, and the content is more preferably from 55 wt% to 95 wt%, still more preferably from 60 wt% to 90 wt%, particularly preferably from 63 wt% to 85 wt%, most preferably from 65 wt% to 80 wt%. All the monomer components may further contain 2-ethylhexyl acrylate (2EHA) at

a ratio smaller than that of n-butyl acrylate (BA).

[0074]

An acrylic polymer in which 2-ethylhexyl acrylate (2EHA) accounts for less than 50 wt% of all the monomer components is given as one embodiment of the acrylic polymer. In this case, the content of 2-ethylhexyl acrylate (2EHA) in all the monomer components is preferably more than 0 wt% and 48 wt% or less because the effects of the present invention can be further expressed, and the content is more preferably from 5 wt% to 45 wt%, still more preferably from 10 wt% to 43 wt%, particularly preferably from 15 wt% to 40 wt%, most preferably from 20 wt% to 35 wt%. All the monomer components may further contain n-butyl acrylate (BA) at a ratio larger than that of 2-ethylhexyl acrylate (2EHA).

[0075]

The acrylic polymer may be copolymerized with any other monomer to such an extent that the effects of the present invention are not impaired. The other monomer may be used for the purpose of, for example, adjusting the glass transition temperature (T_g) of the acrylic polymer or adjusting the pressure-sensitive adhesive performance thereof. As a monomer that may improve the cohesive strength and heat resistance of the pressure-sensitive adhesive, there are given, for example,

a sulfonic acid group-containing monomer, a phosphoric acid group-containing monomer, a cyano group-containing monomer, a vinyl ester, and an aromatic vinyl compound. Of those, a vinyl ester is preferred. Specific examples of the vinyl ester include vinyl acetate (VAc), vinyl propionate, and vinyl laurate. Of those, vinyl acetate (VAc) is preferred.

[0076]

The "other monomers" may be used alone or in combination thereof. The content of the other monomer in all the monomer components is preferably from 0.001 wt% to 40 wt%, more preferably from 0.01 wt% to 40 wt%, still more preferably from 0.1 wt% to 10 wt%, particularly preferably from 0.5 wt% to 5 wt%, most preferably from 1 wt% to 3 wt%.

[0077]

Examples of the other monomer that may introduce a functional group capable of serving as a cross-linking base point into the acrylic polymer, or that may contribute to an improvement in adhesive strength include a hydroxy group (OH group)-containing monomer, a carboxy group-containing monomer, an acid anhydride group-containing monomer, an amide group-containing monomer, an amino group-containing monomer, an imide group-containing monomer, an epoxy group-containing monomer, (meth)acryloylmorpholine, and a vinyl ether.

[0078]

An acrylic polymer copolymerized with the carboxy group-containing monomer as the other monomer is given as one embodiment of the acrylic polymer. Examples of the carboxy group-containing monomer include acrylic acid (AA), methacrylic acid (MAA), carboxyethyl (meth)acrylate, carboxypentyl (meth)acrylate, itaconic acid, maleic acid, fumaric acid, crotonic acid, and isocrotonic acid. Of those, the carboxy group-containing monomer is preferably, for example, acrylic acid (AA) or methacrylic acid (MAA), more preferably acrylic acid (AA) because the effects of the present invention can be further expressed.

[0079]

When the carboxy group-containing monomer is adopted as the other monomer, the content of the other monomer in all the monomer components is preferably from 0.1 wt% to 10 wt% because the effects of the present invention can be further expressed, and the content is more preferably from 0.2 wt% to 8 wt%, still more preferably from 0.5 wt% to 5 wt%, particularly preferably from 0.7 wt% to 4 wt%, most preferably from 1 wt% to 3 wt%.

[0080]

An acrylic polymer copolymerized with the hydroxy group-

containing monomer as the other monomer is given as one embodiment of the acrylic polymer. Examples of the hydroxy group-containing monomer include: hydroxyalkyl (meth)acrylates, such as 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, and 4-hydroxybutyl (meth)acrylate; polypropylene glycol mono(meth)acrylate; and N-hydroxyethyl(meth)acrylamide. Of those, the hydroxy group-containing monomer is preferably, for example, a hydroxyalkyl (meth)acrylate including a linear alkyl group having 2 to 4 carbon atoms because the effects of the present invention can be further expressed, and specific examples thereof include 2-hydroxyethyl acrylate (HEA) and 4-hydroxybutyl acrylate (4HBA). The hydroxy group-containing monomer is more preferably 4-hydroxybutyl acrylate (4HBA).

[0081]

When the hydroxy group-containing monomer is adopted as the other monomer, the content of the other monomer in all the monomer components is preferably from 0.001 wt% to 10 wt% because the effects of the present invention can be further expressed, and the content is more preferably from 0.01 wt% to 5 wt%, still more preferably from 0.02 wt% to 2 wt%, particularly preferably from 0.03 wt% to 1 wt%, most preferably from 0.05 wt% to 0.5 wt%.

[0082]

The Tg of the base polymer may be, for example, -80°C or more because the effects of the present invention can be further expressed. The base polymer (suitably the acrylic polymer) is designed so that its Tg may be preferably -15°C or less from the viewpoint of improving the deformability of the pressure-sensitive adhesive layer with respect to a shear direction. In some embodiments, the Tg of the base polymer is, for example, preferably -25°C or less, more preferably -40°C or less, still more preferably -50°C or less. The base polymer is designed so that its Tg may be, for example, preferably -70°C or more (more preferably -65°C or more, still more preferably -60°C or more) from the viewpoint of improving the cohesiveness and shape recoverability of the polymer.

[0083]

The Tg of the base polymer refers to a value determined from Fox's equation on the basis of the Tg of a homopolymer of each monomer forming the base polymer and the weight fraction (copolymerization ratio on a weight basis) of the monomer. As described below, Fox's equation is a relational equation between the Tg of a copolymer and the glass transition temperature Tgi of a homopolymer obtained by the homopolymerization of each of monomers forming the copolymer.

$$1/T_g = \sum (W_i/T_{gi})$$

[0084]

In Fox's equation described above, T_g represents the glass transition temperature (unit: K) of the copolymer, W_i represents the weight fraction (copolymerization ratio on a weight basis) of a monomer "i" in the copolymer, and T_{gi} represents the glass transition temperature (unit: K) of the homopolymer of the monomer "i". A value described in a known material is adopted as the T_g of a homopolymer.

[0085]

Specifically, for example, the following values may each be used as the T_g of a homopolymer.

2-Ethylhexyl acrylate	-70°C
n-Butyl acrylate	-55°C
Acrylic acid	106°C
2-Hydroxyethyl acrylate	-15°C
4-Hydroxybutyl acrylate	-40°C

[0086]

A numerical value described in "Polymer Handbook" (3rd edition, John Wiley & Sons, Inc., 1989) may be used as the T_g of a homopolymer except those listed above. When a plurality of numerical values are described in the above-mentioned "Polymer

Handbook", a conventional value is adopted. With regard to a monomer that is not described in the above-mentioned "Polymer Handbook", the catalog value of the manufacturer of the monomer is adopted. A value obtained by a measurement method described in JP 2007-51271 A is used as the Tg of a homopolymer of a monomer which is not described in the above-mentioned "Polymer Handbook" and for which the catalog value of the manufacturer of the monomer is not provided.

[0087]

Various polymerization methods known as approaches to synthesizing acrylic polymers, such as a solution polymerization method, an emulsion polymerization method, a bulk polymerization method, and a suspension polymerization method, may each be appropriately adopted as a method of obtaining the acrylic polymer. Of those polymerization methods, the solution polymerization method may be preferably used. A collective loading system involving supplying the total amount of the monomer components in one stroke, a continuous supply (dropping) system, a divided supply (dropping) system, or the like may be appropriately adopted as a monomer supply method at the time of the performance of the solution polymerization. A polymerization temperature may be appropriately selected in accordance with, for example, the kinds of the monomers and a solvent to be used, and the kind of a polymerization initiator.

The polymerization temperature is preferably 20°C or more, more preferably 30°C or more, still more preferably 40°C or more, and is preferably 170°C or less, more preferably 160°C or less, still more preferably 140°C or less. Such active energy ray irradiation polymerization as described below may be adopted as the method of obtaining the acrylic polymer: photopolymerization performed (typically performed in the presence of a photopolymerization initiator) by irradiating the monomer components with light such as UV; or radiation polymerization performed by irradiating the monomer components with a radiation such as a β ray or a γ ray.

[0088]

The solvent (polymerization solvent) to be used in the solution polymerization may be appropriately selected from any appropriate organic solvents. Examples thereof include: aromatic compounds (typically aromatic hydrocarbons), such as toluene; acetic acid esters, such as ethyl acetate; and aliphatic or alicyclic hydrocarbons, such as hexane and cyclohexane.

[0089]

The initiator (polymerization initiator) to be used in the polymerization may be appropriately selected from any appropriate polymerization initiators in accordance with the kind of the polymerization method. The polymerization

initiators may be used alone or in combination thereof. Examples of such polymerization initiator include: azo-based polymerization initiators, such as 2,2'-azobisisobutyronitrile (AIBN); persulfuric acid salts, such as potassium persulfate; peroxide-based initiators, such as benzoyl peroxide and hydrogen peroxide; substituted ethane-based initiators, such as phenyl-substituted ethane; and aromatic carbonyl compounds. Other examples of the polymerization initiator include redox-type initiators each obtained by combining a peroxide and a reducing agent.

[0090]

The usage amount of the polymerization initiator is preferably from 0.005 part by weight to 1 part by weight, more preferably from 0.01 part by weight to 1 part by weight with respect to 100 parts by weight of all the monomer components.

[0091]

The acrylic polymer has an Mw of preferably from 10×10^4 to 500×10^4 , more preferably from 10×10^4 to 150×10^4 , still more preferably from 20×10^4 to 75×10^4 , particularly preferably from 35×10^4 to 65×10^4 . Herein, the Mw refers to a value in terms of standard polystyrene obtained by gel permeation chromatography (GPC). For example, a product available under the model name "HLC-8320GPC" (column: TSKgel GMH-H(S), manufactured by Tosoh

Corporation) may be used as a GPC apparatus.

[0092]

(Tackifying Resin)

The acrylic pressure-sensitive adhesive may contain a tackifying resin because the effects of the present invention can be further expressed. Examples of the tackifying resin include a rosin-based tackifying resin, a terpene-based tackifying resin, a hydrocarbon-based tackifying resin, an epoxy-based tackifying resin, a polyamide-based tackifying resin, an elastomer-based tackifying resin, a phenol-based tackifying resin, and a ketone-based tackifying resin. The tackifying resins may be used alone or in combination thereof.

[0093]

The usage amount of the tackifying resin is preferably from 5 parts by weight to 70 parts by weight with respect to 100 parts by weight of the base polymer because the effects of the present invention can be further expressed, and the usage amount is more preferably from 10 parts by weight to 60 parts by weight, still more preferably from 15 parts by weight to 50 parts by weight, still further more preferably from 20 parts by weight to 45 parts by weight, particularly preferably from 25 parts by weight to 40 parts by weight, most preferably from 25 parts by weight to 35 parts by weight.

[0094]

The tackifying resin preferably contains a tackifying resin TL having a softening point of less than 105°C because the effects of the present invention can be further expressed. The tackifying resin TL can effectively contribute to an improvement in deformability of the pressure-sensitive adhesive layer in its plane direction (shear direction). The softening point of a tackifying resin to be used as the tackifying resin TL is preferably from 50°C to 103°C, more preferably from 60°C to 100°C, still more preferably from 65°C to 95°C, particularly preferably from 70°C to 90°C, most preferably from 75°C to 85°C from the viewpoint of obtaining a higher deformability-improving effect.

[0095]

The softening point of the tackifying resin is defined as a value measured on the basis of a softening point test method (ring and ball method) specified in JIS K 5902 and JIS K 2207. Specifically, the sample is forthwith fused at as low a temperature as possible, and the fused sample is filled into a ring placed on a flat metal plate while attention is paid so that no bubbles may occur therein. After the sample has been cooled, a portion rising from a plane including the upper end of the ring is cut off with a knife that has been somewhat heated. Next, a support (ring stand) is loaded into a glass vessel

(heating bath) having a diameter of 85 mm or more and a height of 127 mm or more, and glycerin is poured into the vessel until its depth becomes 90 mm or more. Next, a steel ball (having a diameter of 9.5 mm and a weight of 3.5 g) and the ring filled with the sample are immersed in glycerin so as not to be in contact with each other, and the temperature of glycerin is kept at $20^{\circ}\text{C} \pm 5^{\circ}\text{C}$ for 15 minutes. Next, the steel ball is mounted on the center of the surface of the sample in the ring, and the resultant is placed at a fixed position on the support. Next, a distance from the upper end of the ring to the surface of glycerin is kept at 50 mm. A temperature gauge is placed in the vessel, and the position of the center of the mercury ball of the temperature gauge is set at the same height as that of the center of the ring, followed by the heating of the vessel. The flame of a Bunsen burner to be used in the heating is brought into contact with a midpoint between the center and edge of the bottom of the vessel so that the heating may be uniformly performed. The rate at which the temperature of the bath increases after having reached 40°C since the start of the heating needs to be $5.0^{\circ}\text{C} \pm 0.5^{\circ}\text{C}$ per minute. A temperature when the sample gradually softens to flow down from the ring, and is finally brought into contact with the bottom plate of the ring is read, and the read temperature is adopted as the softening point. The simultaneous measurement of the softening points of two or more samples is performed, and the average of the measured

values is adopted.

[0096]

The usage amount of the tackifying resin TL is preferably from 5 parts by weight to 50 parts by weight with respect to 100 parts by weight of the base polymer because the effects of the present invention can be further expressed, and the usage amount is more preferably from 10 parts by weight to 45 parts by weight, still more preferably from 15 parts by weight to 40 parts by weight, particularly preferably from 20 parts by weight to 35 parts by weight, most preferably from 25 parts by weight to 32 parts by weight.

[0097]

One or two or more kinds appropriately selected from those each having a softening point of less than 105°C out of the tackifying resins listed above may each be adopted as the tackifying resin TL. The tackifying resin TL preferably contains a rosin-based resin.

[0098]

Examples of the rosin-based resin that may be preferably adopted as the tackifying resin TL include rosin esters, such as an unmodified rosin ester and a modified rosin ester. An example of the modified rosin ester is a hydrogenated rosin ester.

[0099]

The tackifying resin TL preferably contains a hydrogenated rosin ester because the effects of the present invention can be further expressed. The softening point of the hydrogenated rosin ester is preferably less than 105°C because the effects of the present invention can be further expressed, and the softening point is more preferably from 50°C to 100°C, still more preferably from 60°C to 90°C, particularly preferably from 70°C to 85°C, most preferably from 75°C to 85°C.

[0100]

The tackifying resin TL may contain a non-hydrogenated rosin ester. The term "non-hydrogenated rosin ester" as used herein is a concept comprehensively referring to those except the hydrogenated rosin ester out of the above-mentioned rosin esters. Examples of the non-hydrogenated rosin ester include an unmodified rosin ester, a disproportionated rosin ester, and a polymerized rosin ester.

[0101]

The softening point of the non-hydrogenated rosin ester is preferably less than 105°C because the effects of the present invention can be further expressed, and the softening point is more preferably from 50°C to 100°C, still more preferably from

60°C to 90°C, particularly preferably from 70°C to 85°C, most preferably from 75°C to 85°C.

[0102]

The tackifying resin TL may contain any other tackifying resin in addition to the rosin-based resin. One or two or more kinds appropriately selected from those each having a softening point of less than 105°C out of the tackifying resins listed above may each be adopted as the other tackifying resin. The tackifying resin TL may contain, for example, the rosin-based resin and a terpene resin.

[0103]

The content of the rosin-based resin in the entirety of the tackifying resin TL is preferably more than 50 wt% because the effects of the present invention can be further expressed, and the content is more preferably from 55 wt% to 100 wt%, still more preferably from 60 wt% to 99 wt%, particularly preferably from 65 wt% to 97 wt%, most preferably from 75 wt% to 97 wt%.

[0104]

The tackifying resin may contain the tackifying resin TL and a tackifying resin TH having a softening point of 105°C or more (preferably from 105°C to 170°C) in combination because the effects of the present invention can be further expressed.

[0105]

One or two or more kinds appropriately selected from those each having a softening point of 105°C or more out of the tackifying resins listed above may each be adopted as the tackifying resin TH. The tackifying resin TH may contain at least one kind selected from rosin-based tackifying resins (e.g., rosin esters) and terpene-based tackifying resins (e.g., a terpene phenol resin).

[0106]

(Cross-linking Agent)

A cross-linking agent may be incorporated into the acrylic pressure-sensitive adhesive. The cross-linking agents may be used alone or in combination thereof. The use of the cross-linking agent can impart a moderate cohesive strength to the acrylic pressure-sensitive adhesive. The cross-linking agent may be useful in regulating an offset distance and a return distance in a holding power test. The acrylic pressure-sensitive adhesive containing the cross-linking agent may be obtained by, for example, forming the pressure-sensitive adhesive layer through the use of a pressure-sensitive adhesive composition containing the cross-linking agent. The cross-linking agent may be incorporated in, for example, a post-cross-linking reaction form, a pre-cross-linking reaction form, a form partially

subjected to a cross-linking reaction, or an intermediate or composite form thereof into the acrylic pressure-sensitive adhesive. In typical cases, the cross-linking agent is exclusively incorporated in the post-cross-linking reaction form into the acrylic pressure-sensitive adhesive.

[0107]

The usage amount of the cross-linking agent is preferably from 0.005 part by weight to 10 parts by weight with respect to 100 parts by weight of the base polymer because the effects of the present invention can be further expressed, and the usage amount is more preferably from 0.01 part by weight to 7 parts by weight, still more preferably from 0.05 part by weight to 5 parts by weight, particularly preferably from 0.1 part by weight to 4 parts by weight, most preferably from 1 part by weight to 3 parts by weight.

[0108]

Examples of the cross-linking agent include an isocyanate-based cross-linking agent, an epoxy-based cross-linking agent, a silicone-based cross-linking agent, an oxazoline-based cross-linking agent, an aziridine-based cross-linking agent, a silane-based cross-linking agent, an alkyl etherified melamine-based cross-linking agent, a metal chelate-based cross-linking agent, and a cross-linking agent such as a peroxide. Of those, an

isocyanate-based cross-linking agent and an epoxy-based cross-linking agent are preferred, and an isocyanate-based cross-linking agent is more preferred because the effects of the present invention can be further expressed.

[0109]

A compound having two or more isocyanate groups (including an isocyanate regenerative functional group obtained by temporarily protecting an isocyanate group by means of, for example, a blocking agent or oligomerization) in a molecule thereof may be used as the isocyanate-based cross-linking agent. Examples of the isocyanate-based cross-linking agent include: aromatic isocyanates, such as tolylene diisocyanate and xylene diisocyanate; alicyclic isocyanates, such as isophorone diisocyanate; and aliphatic isocyanates, such as hexamethylene diisocyanate.

[0110]

More specific examples of the isocyanate-based cross-linking agent include: lower aliphatic polyisocyanates, such as butylene diisocyanate and hexamethylene diisocyanate; alicyclic isocyanates, such as cyclopentylene diisocyanate, cyclohexylene diisocyanate, and isophorone diisocyanate; aromatic diisocyanates, such as 2,4-tolylene diisocyanate, 4,4'-diphenylmethane diisocyanate, xylylene diisocyanate, and

polymethylene polyphenyl isocyanate; isocyanate adducts, such as a trimethylolpropane/tolylene diisocyanate trimer adduct (e.g., product name: CORONATE L, manufactured by Tosoh Corporation), a trimethylolpropane/hexamethylene diisocyanate trimer adduct (e.g., product name: CORONATE HL, manufactured by Tosoh Corporation), and an isocyanurate form of hexamethylene diisocyanate (e.g., product name: CORONATE HX, manufactured by Tosoh Corporation); a trimethylolpropane adduct of xylylene diisocyanate (e.g., product name: TAKENATE D110N, manufactured by Mitsui Chemicals, Inc.), a trimethylolpropane adduct of xylylene diisocyanate (e.g., product name: TAKENATE D120N, manufactured by Mitsui Chemicals, Inc.), a trimethylolpropane adduct of isophorone diisocyanate (e.g., product name: TAKENATE D140N, manufactured by Mitsui Chemicals, Inc.), and a trimethylolpropane adduct of hexamethylene diisocyanate (e.g., product name: TAKENATE D160N, manufactured by Mitsui Chemicals, Inc.); polyether polyisocyanate, polyester polyisocyanate, and adducts of those compounds and various polyols; and polyisocyanates each of which is polyfunctionalized with an isocyanurate bond, a biuret bond, or an allophanate bond. Of those, aromatic isocyanates and alicyclic isocyanates are preferred from the viewpoint that the deformability and the cohesive strength can be well balanced.

[0111]

The usage amount of the isocyanate-based cross-linking agent is preferably from 0.005 part by weight to 10 parts by weight with respect to 100 parts by weight of the base polymer because the effects of the present invention can be further expressed, and the usage amount is more preferably from 0.01 part by weight to 7 parts by weight, still further more preferably from 0.05 part by weight to 5 parts by weight, particularly preferably from 0.1 part by weight to 4 parts by weight, most preferably from 1 part by weight to 3 parts by weight.

[0112]

When the monomer components forming the acrylic polymer contain a hydroxy group-containing monomer, a weight ratio "isocyanate-based cross-linking agent/hydroxy group-containing monomer" is preferably more than 20 and less than 50 because the effects of the present invention can be further expressed, and the weight ratio is more preferably from 22 to 45, still more preferably from 25 to 40, particularly preferably from 27 to 40, most preferably from 30 to 35.

[0113]

When the acrylic pressure-sensitive adhesive contains the tackifying resin TL having a softening point of less than 105°C, a weight ratio "tackifying resin TL/isocyanate-based cross-

linking agent" is preferably more than 2 and less than 15 because the effects of the present invention can be further expressed, and the weight ratio is more preferably from 5 to 13, still more preferably from 7 to 12, particularly preferably from 7 to 11.

[0114]

A polyfunctional epoxy compound having two or more epoxy groups in a molecule thereof may be used as the epoxy-based cross-linking agent. Examples of the epoxy-based cross-linking agent include N,N,N',N'-tetraglycidyl-m-xylenediamine, diglycidylaniline, 1,3-bis(N,N-diglycidylaminomethyl)cyclohexane, 1,6-hexanediol diglycidyl ether, neopentyl glycol diglycidyl ether, ethylene glycol diglycidyl ether, propylene glycol diglycidyl ether, polyethylene glycol diglycidyl ether, polypropylene glycol diglycidyl ether, sorbitol polyglycidyl ether, glycerol polyglycidyl ether, pentaerythritol polyglycidyl ether, polyglycerol polyglycidyl ether, sorbitan polyglycidyl ether, trimethylolpropane polyglycidyl ether, adipic acid diglycidyl ester, o-phthalic acid diglycidyl ester, triglycidyl-tris(2-hydroxyethyl) isocyanurate, resorcin diglycidyl ether, bisphenol-S-diglycidyl ether, and an epoxy-based resin having two or more epoxy groups in a molecule thereof. As a commercial product of the epoxy-based cross-linking agent, there is given, for example, a product available under the product name "TETRAD

C" or "TETRAD X" from Mitsubishi Gas Chemical Company.

[0115]

The usage amount of the epoxy-based cross-linking agent is preferably from 0.005 part by weight to 10 parts by weight with respect to 100 parts by weight of the base polymer because the effects of the present invention can be further expressed, and the usage amount is more preferably from 0.01 part by weight to 5 parts by weight, still more preferably from 0.015 part by weight to 1 part by weight, particularly preferably from 0.15 part by weight to 0.5 part by weight, most preferably from 0.015 part by weight to 0.3 part by weight.

[0116]

(Other Components)

The acrylic pressure-sensitive adhesive may contain any of various additives that are general in the field of a pressure-sensitive adhesive, such as a leveling agent, a cross-linking aid, a plasticizer, a softening agent, a filler, an antistatic agent, an age resistor, a UV absorber, an antioxidant, and a light stabilizer, as required. Conventionally known additives may be used as such various additives by ordinary methods.

[0117]

<<Antistatic Layer>>

The pressure-sensitive adhesive film of the present invention may include an antistatic layer on the surface of the base material layer opposite to the surface thereof having the pressure-sensitive adhesive layer. A mode in which the pressure-sensitive adhesive film of the present invention includes the antistatic layer on the surface of the base material layer opposite to the surface thereof having the pressure-sensitive adhesive layer is preferred because the charging of the pressure-sensitive adhesive film itself can be suppressed, and hence dust hardly adsorbs thereto.

[0118]

A method of forming the antistatic layer is, for example, a method including applying an antistatic resin formed of an antistatic agent and a resin component, a conductive polymer, or a conductive resin containing a conductive substance to the base material layer, or a method including vapor-depositing or plating the conductive substance onto the base material layer.

[0119]

Examples of the antistatic agent to be incorporated into the antistatic resin include: cationic antistatic agents each having a cationic functional group, such as a quaternary ammonium salt, a pyridinium salt, and primary, secondary, and tertiary amino groups; anionic antistatic agents each having an anionic

functional group, such as a sulfonic acid salt, a sulfuric acid ester salt, a phosphonic acid salt, and a phosphoric acid ester salt; amphoteric antistatic agents, such as an alkylbetaine and a derivative thereof, imidazoline and a derivative thereof, and alanine and a derivative thereof; nonionic antistatic agents, such as an aminoalcohol and a derivative thereof, glycerin and a derivative thereof, and polyethylene glycol and a derivative thereof; and an ion conductive polymer obtained by polymerizing or copolymerizing any one of the monomers each having a cationic, anionic, or amphoteric ion conductive group. Those antistatic agents may be used alone or in combination thereof.

[0120]

Examples of the cationic antistatic agent include: (meth)acrylate copolymers each having a quaternary ammonium group, such as an alkyltrimethylammonium salt, acyloylamidopropyltrimethylammonium methosulfate, an alkylbenzylmethylammonium salt, acyl choline chloride, and polydimethylaminoethyl methacrylate; styrene copolymers each having a quaternary ammonium group, such as polyvinylbenzyltrimethylammonium chloride; and diallylamine copolymers each having a quaternary ammonium group, such as polydiallyldimethylammonium chloride. Those antistatic agents may be used alone or in combination thereof.

[0121]

Examples of the anionic antistatic agent include an alkyl sulfonic acid salt, an alkylbenzene sulfonic acid salt, an alkyl sulfuric acid ester salt, an alkylethoxysulfuric acid ester salt, an alkyl phosphoric acid ester salt, and a sulfonic acid group-containing styrene copolymer. Those antistatic agents may be used alone or in combination thereof.

[0122]

Examples of the amphoteric antistatic agent include an alkylbetaine, an alkylimidazolium betaine, and a carbobetaine graft copolymer. Those antistatic agents may be used alone or in combination thereof.

[0123]

Examples of the nonionic antistatic agent include a fatty acid alkylolamide, a di(2-hydroxyethyl)alkylamine, a polyoxyethylene alkylamine, a fatty acid glycerin ester, a polyoxyethylene glycol fatty acid ester, a sorbitan fatty acid ester, a polyoxysorbitan fatty acid ester, a polyoxyethylene alkyl phenyl ether, a polyoxyethylene alkyl ether, polyethylene glycol, polyoxyethylenediamine, a copolymer formed of polyether, polyester, and polyamide, and methoxypolyethylene glycol (meth)acrylate. Those antistatic agents may be used alone or in combination thereof.

[0124]

Examples of the conductive polymer include polyaniline, polypyrrole, and polythiophene. Those conductive polymers may be used alone or in combination thereof.

[0125]

Examples of the conductive substance include tin oxide, antimony oxide, indium oxide, cadmium oxide, titanium oxide, zinc oxide, indium, tin, antimony, gold, silver, copper, aluminum, nickel, chromium, titanium, iron, cobalt, and copper iodide, and alloys or mixtures thereof. Those conductive substances may be used alone or in combination thereof.

[0126]

As the resin component to be used in the antistatic resin and the conductive resin, there is used, for example, a general resin, such as a polyester resin, an acrylic resin, a polyvinyl resin, a urethane resin, a melamine resin, or an epoxy resin. When a polymer-type antistatic agent is used, the resin component may not be incorporated. In addition, as a cross-linking agent serving as a component of the antistatic resin, for example, the following components may be incorporated: a methylolized or alkylolized melamine-based compound, urea-based compound, glyoxazole-based compound, or acrylamide-based compound; an

epoxy compound; and an isocyanate compound.

[0127]

The antistatic layer is formed by, for example, a method including diluting the above-mentioned antistatic resin, conductive polymer, conductive resin, or the like with a solvent such as an organic solvent or water, applying the application liquid to a base material or the like, and drying the liquid.

[0128]

Examples of the diluting solution to be used in the formation of the antistatic layer include methyl ethyl ketone, acetone, ethyl acetate, tetrahydrofuran, dioxane, cyclohexanone, n-hexane, toluene, xylene, methanol, ethanol, n-propanol, isopropanol, and water. Those solvents may be used alone or in combination thereof.

[0129]

Any appropriate application method is appropriately used as a method for the application in the formation of the antistatic layer. Examples of such application method include roll coating, gravure coating, reverse coating, roll brush coating, spray coating, air knife coating, impregnation, and curtain coating.

[0130]

Any appropriate method is appropriately used as a method for the vapor deposition or plating of the conductive substance. Examples of such method include vacuum deposition, sputtering, ion plating, chemical vapor deposition, spray pyrolysis, chemical plating, and an electroplating method.

[0131]

Any appropriate thickness may be adopted as the thickness of the antistatic layer to such an extent that the effects of the present invention are not impaired. The thickness of the antistatic layer is preferably from 0.001 μm to 5 μm because the effects of the present invention can be further expressed, and the thickness is more preferably from 0.005 μm to 1 μm .

[0132]

<<Top Coat Layer>>

The pressure-sensitive adhesive film of the present invention may include a top coat layer on the surface of the base material layer opposite to the surface thereof having the pressure-sensitive adhesive layer. The top coat layer preferably contains a binder, and more preferably contains the binder and a slip additive. A mode in which the pressure-sensitive adhesive film of the present invention includes the top coat layer is preferred because the scratch resistance of

the pressure-sensitive adhesive film is improved.

[0133]

<Binder>

Any appropriate resin may be adopted as the binder to such an extent that the effects of the present invention are not impaired. Such resin is preferably at least one kind selected from the group consisting of a polyester resin and a urethane-based resin because the effects of the present invention can be further expressed.

[0134]

(Polyester Resin)

When the polyester resin is incorporated into the binder, the polyester resins may be used alone or in combination thereof.

[0135]

The polyester resin is preferably a resin containing polyester as a main component. The content of the polyester in the polyester resin is preferably more than 50 wt%, more preferably 75 wt% or more, still more preferably 90 wt% or more.

[0136]

The polyester preferably has a structure in which at least one kind of compound (polyvalent carboxylic acid component)

selected from polyvalent carboxylic acids (preferably dicarboxylic acids) each having two or more carboxyl groups in a molecule thereof and derivatives thereof (e.g., anhydrides, esterified products, and halides of the polyvalent carboxylic acids), and at least one kind of compound (polyhydric alcohol component) selected from polyhydric alcohols (preferably diols) each having two or more hydroxy groups in a molecule thereof are condensed with each other.

[0137]

Examples of the compound that may be adopted as the polyvalent carboxylic acid component include: aliphatic dicarboxylic acids, such as oxalic acid, malonic acid, difluoromalonic acid, an alkylmalonic acid, succinic acid, tetrafluorosuccinic acid, an alkylsuccinic acid, ($\pm$)-malic acid, meso-tartaric acid, itaconic acid, maleic acid, methylmaleic acid, fumaric acid, methylfumaric acid, acetylenedicarboxylic acid, glutaric acid, hexafluoroglutaric acid, methylglutaric acid, glutaconic acid, adipic acid, dithioadipic acid, methyladipic acid, dimethyladipic acid, tetramethyladipic acid, methyleneadipic acid, muconic acid, galactaric acid, pimelic acid, suberic acid, perfluorosuberic acid, 3,3,6,6-tetramethylsuberic acid, azelaic acid, sebacic acid, perfluorosebacic acid, brassylic acid, dodecyldicarboxylic acid, tridecyldicarboxylic acid, and tetradecyldicarboxylic acid;

alicyclic dicarboxylic acids, such as a cycloalkyldicarboxylic acid (e.g., 1,4-cyclohexanedicarboxylic acid or 1,2-cyclohexanedicarboxylic acid), 1,4-(2-norbornene)dicarboxylic acid, 5-norbornene-2,3-dicarboxylic acid (himic acid), adamantanedicarboxylic acid, and spiroheptanedicarboxylic acid; aromatic dicarboxylic acids, such as phthalic acid, isophthalic acid, dithioisophthalic acid, methylisophthalic acid, dimethylisophthalic acid, chloroisophthalic acid, dichloroisophthalic acid, terephthalic acid, methylterephthalic acid, dimethylterephthalic acid, chloroterephthalic acid, bromoterephthalic acid, naphthalenedicarboxylic acid, oxofluorenedicarboxylic acid, anthracenedicarboxylic acid, biphenyldicarboxylic acid, biphenylenedicarboxylic acid, dimethylbiphenylenedicarboxylic acid, 4,4''-p-terphenylenedicarboxylic acid, 4,4''-p-quarterphenyldicarboxylic acid, bibenzoyldicarboxylic acid, azobenzenedicarboxylic acid, homophthalic acid, phenylenediacetic acid, phenylenedipropionic acid, naphthalenedicarboxylic acid, naphthalenedipropionic acid, biphenyldiacetic acid, biphenyldipropionic acid, 3,3'-[4,4'-(methylene di-p-biphenylene)dipropionic acid, 4,4'-bibenzoyldiacetic acid, 3,3'-(4,4'-bibenzyl)dipropionic acid, and oxy-di-p-phenylenediacetic acid; an acid anhydride of any of the above-mentioned polyvalent carboxylic acids; an ester (e.g., an alkyl ester, a monoester, or a diester) of any of the above-

mentioned polyvalent carboxylic acids; and an acid halide (e.g., a dicarboxylic acid chloride) corresponding to any of the above-mentioned polyvalent carboxylic acids.

[0138]

Suitable examples of the compound that may be adopted as the polyvalent carboxylic acid component include: aromatic dicarboxylic acids, such as terephthalic acid, isophthalic acid, and naphthalenedicarboxylic acid, and acid anhydrides thereof; aliphatic dicarboxylic acids, such as adipic acid, sebacic acid, azelaic acid, succinic acid, fumaric acid, maleic acid, himic acid, and 1,4-cyclohexanedicarboxylic acid, and acid anhydrides thereof; and lower alkyl esters of the above-mentioned dicarboxylic acids (e.g., an ester with a monoalcohol having 1 to 3 carbon atoms).

[0139]

Examples of the compound that may be adopted as the polyhydric alcohol component include diols, such as ethylene glycol, propylene glycol, 1,2-propanediol, 1,3-propanediol, 1,3-butanediol, 1,4-butanediol, neopentyl glycol, 1,5-pentanediol, 1,6-hexanediol, 3-methylpentanediol, diethylene glycol, 1,4-cyclohexanedimethanol, 3-methyl-1,5-pentanediol, 2-methyl-1,3-propanediol, 2,2-diethyl-1,3-propanediol, 2-butyl-2-ethyl-1,3-propanediol, xylylene glycol, hydrogenated bisphenol A, and

bisphenol A. Other examples thereof include alkylene oxide adducts (e.g., an ethylene oxide adduct and a propylene oxide adduct) of those compounds.

[0140]

The polyester resin preferably contains water-dispersible polyester, and more preferably contains the water-dispersible polyester as a main component. Such water-dispersible polyester may be, for example, polyester improved in water dispersibility by introducing a hydrophilic functional group (e.g., at least one kind selected from hydrophilic functional groups, such as a sulfonic acid metal salt group, a carboxyl group, an ether group, and a phosphoric acid group) into the polymer. As an approach to introducing a hydrophilic functional group into the polymer as described above, there may be appropriately adopted any appropriate approach, such as a method including copolymerizing compounds each having a hydrophilic functional group, or a method including modifying the polyester or a precursor thereof (e.g., the polyvalent carboxylic acid component or the polyhydric alcohol component, or an oligomer thereof) to produce a hydrophilic functional group. Preferred water-dispersible polyester is, for example, polyester (copolymerized polyester) obtained by copolymerizing compounds each having a hydrophilic functional group.

[0141]

The polyester resin to be used as the binder may contain saturated polyester as a main component, or may contain unsaturated polyester as a main component. The main component of the polyester resin is preferably the saturated polyester, more preferably saturated polyester having imparted thereto water dispersibility (e.g., saturated copolymerized polyester). Such polyester resin (polyester resin that may be prepared in the form of an aqueous dispersion liquid) may be synthesized by any appropriate method, or a commercial product thereof is easily available.

[0142]

The molecular weight of the polyester resin as a weight-average molecular weight (Mw) in terms of standard polystyrene measured by gel permeation chromatograph (GPC) is preferably from 0.5×10^4 to 15×10^4 , more preferably from 1×10^4 to 6×10^4 .

[0143]

The glass transition temperature (Tg) of the polyester resin is preferably from 0°C to 100°C, more preferably from 10°C to 80°C.

[0144]

(Urethane-based Resin)

When the urethane-based resin is incorporated into the binder, the urethane-based resins may be used alone or in combination thereof.

[0145]

The urethane-based resin is preferably a urethane-based resin obtained by curing a composition containing a polyol (A) and a polyfunctional isocyanate compound (B).

[0146]

The polyols (A) may be used alone or in combination thereof.

[0147]

Any appropriate polyol may be adopted as the polyol (A) as long as the polyol has two or more OH groups. Examples of such polyol (A) include a polyol (diol) having two OH groups, a polyol (triol) having three OH groups, a polyol (tetraol) having four OH groups, a polyol (pentaol) having five OH groups, and a polyol (hexaol) having six OH groups.

[0148]

A glycol having two or more OH groups, such as ethylene glycol or propylene glycol, is preferably adopted as an essential component for the polyol (A). When the glycol is adopted as the essential component as described above, there may be provided,

for example, a urethane-based curing resin excellent in strength of a coating film after its curing, and excellent in adhesiveness with the base material and added substance-holding property. The content of the glycol in the polyol (A) is preferably from 30 wt% to 100 wt%, more preferably from 50 wt% to 100 wt%, still more preferably from 70 wt% to 100 wt%, still further more preferably from 90 wt% to 100 wt%, particularly preferably from 95 wt% to 100 wt%, most preferably substantially 100 wt%.

[0149]

Examples of the polyol (A) include ethylene glycol, diethylene glycol, propylene glycol, 1,3-butanediol, 1,4-butanediol, neopentyl glycol, 3-methyl-1,5-pentanediol, 2-butyl-2-ethyl-1,3-propanediol, 2,4-diethyl-1,5-pentanediol, 1,2-hexanediol, 1,6-hexanediol, 1,8-octanediol, 1,9-nonanediol, 2-methyl-1,8-octanediol, 1,8-decanediol, octadecanediol, glycerin, trimethylolpropane, pentaerythritol, hexanetriol, polyethylene glycol, polypropylene glycol, polyester polyol, polyether polyol, polycaprolactone polyol, polycarbonate polyol, and a castor oil-based polyol.

[0150]

The polyester polyol may be obtained by, for example, an esterification reaction between a polyol component and an acid component.

[0151]

Examples of the acid component include succinic acid, methylsuccinic acid, adipic acid, pimelic acid, azelaic acid, sebacic acid, 1,12-dodecanedioic acid, 1,14-tetradecanedioic acid, a dimer acid, 2-methyl-1,4-cyclohexanedicarboxylic acid, 2-ethyl-1,4-cyclohexanedicarboxylic acid, terephthalic acid, isophthalic acid, phthalic acid, isophthalic acid, terephthalic acid, 1,4-naphthalenedicarboxylic acid, and 4,4'-biphenyldicarboxylic acid, and acid anhydrides thereof.

[0152]

An example of the polyether polyol is a polyether polyol obtained by subjecting an alkylene oxide, such as ethylene oxide, propylene oxide, or butylene oxide, to addition polymerization through the use of, for example, water, a low-molecular-weight polyol (e.g., propylene glycol, ethylene glycol, glycerin, trimethylolpropane, or pentaerythritol), a bisphenol (e.g., bisphenol A), or a dihydroxybenzene (e.g., catechol, resorcin, or hydroquinone) as an initiator. Specific examples thereof include polyethylene glycol, polypropylene glycol, and polytetramethylene glycol.

[0153]

An example of the polycaprolactone polyol is a

caprolactone-based polyester diol obtained by ring-opening polymerization of a cyclic ester monomer, such as ϵ -caprolactone or σ -valerolactone.

[0154]

Examples of the polycarbonate polyol include: a polycarbonate polyol obtained by subjecting the above-mentioned polyol component and phosgene to a polycondensation reaction; a polycarbonate polyol obtained by transesterification condensation of the above-mentioned polyol component and a carbonic acid diester, such as dimethyl carbonate, diethyl carbonate, dipropyl carbonate, diisopropyl carbonate, dibutyl carbonate, ethyl butyl carbonate, ethylene carbonate, propylene carbonate, diphenyl carbonate, or dibenzyl carbonate; a copolymerized polycarbonate polyol obtained by using two or more kinds of the above-mentioned polyol components in combination; a polycarbonate polyol obtained by subjecting any of the above-mentioned various polycarbonate polyols and a carboxyl group-containing compound to an esterification reaction; a polycarbonate polyol obtained by subjecting any of the above-mentioned various polycarbonate polyols and a hydroxyl group-containing compound to an etherification reaction; a polycarbonate polyol obtained by subjecting any of the above-mentioned various polycarbonate polyols and an ester compound to a transesterification reaction; a polycarbonate polyol obtained

by subjecting any of the above-mentioned various polycarbonate polyols and a hydroxyl group-containing compound to a transesterification reaction; a polyester-based polycarbonate polyol obtained by subjecting any of the above-mentioned various polycarbonate polyols and a dicarboxylic acid compound to a polycondensation reaction; and a copolymerized polyether-based polycarbonate polyol obtained by copolymerizing any of the above-mentioned various polycarbonate polyols and an alkylene oxide.

[0155]

The castor oil-based polyol is, for example, a castor oil-based polyol obtained by causing a castor oil fatty acid and the above-mentioned polyol component to react with each other. The castor oil-based polyol is specifically, for example, a castor oil-based polyol obtained by causing the castor oil fatty acid and polypropylene glycol to react with each other.

[0156]

The polyfunctional isocyanate compounds (B) may be used alone or in combination thereof.

[0157]

Any appropriate polyfunctional isocyanate compound that may be used in a urethanization reaction may be adopted as the

polyfunctional isocyanate compound (B). Examples of such polyfunctional isocyanate compound (B) include a polyfunctional aliphatic isocyanate compound, a polyfunctional alicyclic isocyanate, and a polyfunctional aromatic isocyanate compound.

[0158]

Examples of the polyfunctional aliphatic isocyanate compound include trimethylene diisocyanate, tetramethylene diisocyanate, hexamethylene diisocyanate, pentamethylene diisocyanate, 1,2-propylene diisocyanate, 1,3-butylenediisocyanate, dodecamethylene diisocyanate, and 2,4,4-trimethylhexamethylene diisocyanate.

[0159]

Examples of the polyfunctional alicyclic isocyanate compound include 1,3-cyclopentenediisocyanate, 1,3-cyclohexanediisocyanate, 1,4-cyclohexanediisocyanate, isophoronediiisocyanate, hydrogenated diphenylmethane diisocyanate, hydrogenated xylylenediisocyanate, hydrogenated tolylenediisocyanate, and hydrogenated tetramethylxylylenediisocyanate.

[0160]

Examples of the polyfunctional aromatic diisocyanate compound include phenylenediisocyanate, 2,4-tolylenediisocyanate, 2,6-tolylenediisocyanate, 2,2'-diphenylmethane

diisocyanate, 4,4'-diphenylmethane diisocyanate, 4,4'-toluidine diisocyanate, 4,4'-diphenyl ether diisocyanate, 4,4'-diphenyl diisocyanate, 1,5-naphthalene diisocyanate, and xylylene diisocyanate.

[0161]

Examples of the polyfunctional isocyanate compound (B) also include trimethylolpropane adducts, biurets obtained by reaction with water, and trimers each having an isocyanurate ring, of the above-mentioned various polyfunctional isocyanate compounds. In addition, those compounds may be used in combination thereof.

[0162]

The content of the polyfunctional isocyanate compound (B) is preferably from 5 wt% to 60 wt%, more preferably from 8 wt% to 60 wt%, still more preferably from 10 wt% to 60 wt% with respect to the polyol (A). When the content of the polyfunctional isocyanate compound (B) is adjusted within the ranges, the effects of the present invention can be still further expressed.

[0163]

The urethane-based resin is typically obtained by curing the composition containing the polyol (A) and the polyfunctional

isocyanate compound (B). Any appropriate other component except the polyol (A) and the polyfunctional isocyanate compound (B) may be incorporated into such composition to such an extent that the effects of the present invention are not impaired. Examples of such other component include a catalyst, any other resin component except a polyurethane-based resin, a tackifier, an inorganic filler, an organic filler, metal powder, a pigment, a foil-like product, a softening agent, a plasticizer, an age resistor, a conductive agent, an antioxidant, a UV absorber, a light stabilizer, a surface lubricant, a leveling agent, a corrosion inhibitor, a thermal stabilizer, a polymerization inhibitor, a lubricant, and a solvent.

[0164]

Any appropriate method, such as a urethanization reaction method including using bulk polymerization, solution polymerization, or the like, may be adopted as a method of curing the composition containing the polyol (A) and the polyfunctional isocyanate compound (B) to provide the urethane-based resin to such an extent that the effects of the present invention are not impaired.

[0165]

(Other Resin)

The top coat layer may further contain any other resin

except the polyester resin and the urethane-based resin (e.g., at least one kind of resin selected from an acrylic resin, an acrylic-styrene resin, an acrylic-silicone resin, a silicone resin, a polysilazane resin, a fluorine resin, and a polyolefin resin) as the binder to such an extent that the performance of the pressure-sensitive adhesive film is not largely impaired. As a preferred embodiment of the top coat layer, the binder of the top coat layer is formed substantially only of at least one kind selected from the group consisting of the polyester resin and the urethane-based resin, and the ratio of the at least one kind selected from the group consisting of the polyester resin and the urethane-based resin to the binder is preferably from 98 wt% to 100 wt%, more preferably from 99 wt% to 100 wt%, still more preferably from 99.5 wt% to 100 wt%. The ratio of the binder to the entirety of the top coat layer is preferably from 15 wt% to 95 wt%, more preferably from 25 wt% to 80 wt%.

[0166]

<Slip Additive>

The top coat layer preferably contains, as the slip additive, an ester of a higher fatty acid and a higher alcohol (hereinafter sometimes referred to as "wax ester").

[0167]

The "higher fatty acid" is preferably a carboxylic acid

having 8 or more carbon atoms, and its number of carbon atoms is more preferably 10 or more, still more preferably from 10 to 40. The carboxylic acid is preferably a monovalent carboxylic acid.

[0168]

The "higher alcohol" is preferably an alcohol having 6 or more carbon atoms, and its number of carbon atoms is more preferably 10 or more, still more preferably from 10 to 40. The alcohol is preferably a monohydric or dihydric alcohol, more preferably a monohydric alcohol.

[0169]

The top coat layer of such composition as to contain such wax ester and the binder described above in combination hardly whitens even when held under high-temperature and high-humidity conditions. Therefore, a pressure-sensitive adhesive film including a base material having such top coat layer may have higher appearance quality.

[0170]

A possible reason why excellent whitening resistance (e.g., the property by which the top coat layer hardly whitens even when held under high-temperature and high-humidity conditions) is achieved by the top coat layer of the above-mentioned composition is, for example, the following reason. That is, a

silicone-based lubricant that has heretofore been used is assumed to bleed to the surface of the top coat layer to exhibit a function of imparting slipperiness to the surface. However, the extent to which such silicone-based lubricant bleeds is liable to vary owing to a difference in storage condition (e.g., a temperature, a humidity, or an elapsed time). Accordingly, for example, when the usage amount of the silicone-based lubricant is set so that in the case where the pressure-sensitive adhesive film is stored under normal storage conditions (e.g., 25°C and 50%RH), moderate slipperiness may be obtained over a relatively long time period (e.g., about 3 months) from a time point immediately after the production of the pressure-sensitive adhesive film, in the case where the pressure-sensitive adhesive film is stored under high-temperature and high-humidity conditions (e.g., 60°C and 95%RH) for 2 weeks, the bleeding of the lubricant excessively advances. The silicone-based lubricant that has excessively bled as described above may whiten the top coat layer (and by extension, the pressure-sensitive adhesive film).

[0171]

A specific combination of the wax ester serving as the slip additive and the polyester resin serving as the binder is adopted as a preferred embodiment of the top coat layer. Such combination of the slip additive and the binder makes the extent

to which the wax ester bleeds from the top coat layer less susceptible to the storage conditions. Thus, the whitening resistance of the pressure-sensitive adhesive film can be improved.

[0172]

One or more kinds of compounds each represented by the general formula (W) may each be preferably adopted as the wax ester.

X-COO-Y

(W)

[0173]

In the formula (W), X and Y preferably each independently represent a hydrocarbon group having 10 to 40 carbon atoms, and its number of carbon atoms is more preferably from 10 to 35, still more preferably from 14 to 35, particularly preferably from 20 to 32. When the number of carbon atoms is excessively small, the slipperiness-imparting effect of the wax ester on the top coat layer may be insufficient. The hydrocarbon group may be a saturated hydrocarbon group, or may be an unsaturated hydrocarbon group. The hydrocarbon group is preferably a saturated hydrocarbon group. In addition, the hydrocarbon group may be of a structure containing an aromatic ring, may be of a structure free of any aromatic ring (aliphatic hydrocarbon

group), may be a hydrocarbon group of a structure containing an aliphatic ring (alicyclic hydrocarbon group), or may be a chain hydrocarbon group (including linear and branched groups).

[0174]

The wax ester is a compound in which X and Y in the formula (W) each independently represent preferably a chain alkyl group having 10 to 40 carbon atoms, more preferably a linear alkyl group having 10 to 40 carbon atoms. Specific examples of such compound include myricyl cerotate ($\text{CH}_3(\text{CH}_2)_{24}\text{COO}(\text{CH}_2)_{29}\text{CH}_3$), myricyl palmitate ($\text{CH}_3(\text{CH}_2)_{14}\text{COO}(\text{CH}_2)_{29}\text{CH}_3$), cetyl palmitate ($\text{CH}_3(\text{CH}_2)_{14}\text{COO}(\text{CH}_2)_{15}\text{CH}_3$), and stearyl stearate ($\text{CH}_3(\text{CH}_2)_{16}\text{COO}(\text{CH}_2)_{17}\text{CH}_3$).

[0175]

The melting point of the wax ester is preferably 50°C or more, more preferably 60°C or more, still more preferably 70°C or more, particularly preferably 75°C or more. Such wax ester can achieve higher whitening resistance. The melting point of the wax ester is preferably 100°C or less. Such wax ester has a high slipperiness-imparting effect, and hence can form a top coat layer having higher scratch resistance. The melting point of the wax ester is preferably 100°C or less also because an aqueous dispersion liquid of the wax ester is easily prepared. For example, myricyl cerotate may be preferably adopted as such

wax ester.

[0176]

A natural wax containing such wax ester may be utilized as a raw material for the top coat layer. In such natural wax, the content of the wax ester (when the wax contains two or more kinds of wax esters, the total of their contents) is preferably more than 50 wt%, more preferably 65 wt% or more, still more preferably 75 wt% or more with respect to a nonvolatile content (NV). Examples of such natural wax include: vegetable waxes, such as a carnauba wax (generally containing myricyl cerotate at a ratio of preferably 60 wt% or more, more preferably 70 wt% or more, still more preferably 80 wt% or more) and a palm wax; and animal waxes, such as a beeswax and a spermaceti wax. The melting point of such natural wax is preferably 50°C or more, more preferably 60°C or more, still more preferably 70°C or more, particularly preferably 75°C or more. A chemically synthesized wax ester may be used as a raw material for the top coat layer, or the natural wax refined to have a higher purity of the wax ester may be used. Those raw materials may be used alone or in combination thereof.

[0177]

The ratio of the slip additive to the entirety of the top coat layer is preferably from 5 wt% to 50 wt%, more preferably

from 10 wt% to 40 wt%. When the content of the slip additive is excessively small, the scratch resistance of the layer may be liable to reduce. When the content of the slip additive is excessively large, the whitening resistance-improving effect of the layer may be liable to be insufficient.

[0178]

The top coat layer may contain any other slip additive in addition to the wax ester. Examples of the other slip additive include various waxes except the wax ester, such as a petroleum-based wax (e.g., a paraffin wax), a mineral-based wax (e.g., a montan wax), a higher fatty acid (e.g., cerotic acid), and a neutral fat (e.g., palmitic acid triglyceride). In addition, a silicone-based lubricant, a fluorine-based lubricant, or the like may be incorporated into the layer in addition to the wax ester. A preferred embodiment of the top coat layer is an embodiment in which the layer is substantially free of the silicone-based lubricant and the fluorine-based lubricant. For example, the total content of the silicone-based lubricant and the fluorine-based lubricant in the entirety of the top coat layer is preferably 0.01 wt% or less, more preferably a detection limit or less.

[0179]

The top coat layer may contain, as required, an additive,

such as an antistatic component, a cross-linking agent, an antioxidant, a colorant (e.g., a pigment or a dye), a flowability-adjusting agent (e.g., a thixotropic agent or a thickening agent), a film-forming aid, a surfactant (e.g., an antifoaming agent or a dispersant), or an antiseptic agent.

[0180]

<Antistatic Component of Top Coat Layer>

As a preferred embodiment, the top coat layer contains the antistatic component. The antistatic component is a component that can exhibit a preventing or suppressing action on the charging of the pressure-sensitive adhesive film. When the antistatic component is incorporated into the top coat layer, for example, organic or inorganic conductive substances, and various antistatic agents may each be used as the antistatic component. In addition, the antistatic agents that may be used in the antistatic layer described above may each be used.

[0181]

Examples of the organic conductive substance include: cationic antistatic agents each having a cationic functional group, such as a quaternary ammonium salt, a pyridinium salt, a primary amino group, a secondary amino group, and a tertiary amino group; anionic antistatic agents each having an anionic functional group, such as a sulfonic acid salt, a sulfuric acid

ester salt, a phosphonic acid salt, and a phosphoric acid ester salt; amphoteric antistatic agents, such as an alkylbetaine and derivatives thereof, imidazoline and derivatives thereof, and alanine and derivatives thereof; nonionic antistatic agents, such as an amino alcohol and derivatives thereof, glycerin and derivatives thereof, and polyethylene glycol and derivatives thereof; ion conductive polymers each obtained by polymerizing or copolymerizing a monomer having the above-mentioned cationic, anionic, or amphoteric ion conductive group (e.g., a quaternary ammonium salt group); and conductive polymers, such as polythiophene, polyaniline, polypyrrole, polyethylene imine, and an allylamine-based polymer. Such antistatic agents may be used alone or in combination thereof.

[0182]

Examples of the inorganic conductive substance include tin oxide, antimony oxide, indium oxide, cadmium oxide, titanium oxide, zinc oxide, indium, tin, antimony, gold, silver, copper, aluminum, nickel, chromium, titanium, iron, cobalt, copper iodide, ITO (indium oxide/tin oxide), and ATO (antimony oxide/tin oxide). Such inorganic conductive substances may be used alone or in combination thereof.

[0183]

Examples of the antistatic agent include a cationic

antistatic agent, an anionic antistatic agent, an amphoteric antistatic agent, a nonionic antistatic agent, and an ion conductive polymer obtained by polymerizing or copolymerizing a monomer having the above-mentioned cationic, anionic, or amphoteric ion conductive group.

[0184]

When the top coat layer contains the antistatic component, the antistatic component preferably contains an organic conductive substance. Various conductive polymers may each be preferably used as the organic conductive substance. Such configuration can achieve both of a satisfactory antistatic property and high scratch resistance.

[0185]

Examples of the conductive polymers include polythiophene, polyaniline, polypyrrole, polyethylene imine, and an allylamine-based polymer. Such conductive polymers may be used alone or in combination thereof. In addition, any such polymer may be used in combination with any other antistatic component (e.g., an inorganic conductive substance or an antistatic agent).

[0186]

The usage amount of the conductive polymer is preferably from 1 part by weight to 100 parts by weight, more preferably

from 2 parts by weight to 70 parts by weight, still more preferably from 3 parts by weight to 50 parts by weight with respect to 100 parts by weight of the binder in the top coat layer. When the usage amount of the conductive polymer is excessively small, its antistatic effect may reduce. When the usage amount of the conductive polymer is excessively large, the compatibility of the conductive polymer in the top coat layer may tend to be insufficient to reduce the appearance quality of the top coat layer or to reduce the solvent resistance thereof.

[0187]

The conductive polymer is preferably, for example, the polythiophene or the polyaniline. The weight-average molecular weight M_w of the polythiophene in terms of polystyrene is preferably 40×10^4 or less, more preferably 30×10^4 or less. The weight-average molecular weight M_w of the polyaniline in terms of polystyrene is preferably 50×10^4 or less, more preferably 30×10^4 or less. The weight-average molecular weight M_w of the conductive polymer in terms of polystyrene is preferably 0.1×10^4 or more, more preferably 0.5×10^4 or more. The term "polythiophene" as used herein refers to a polymer of unsubstituted thiophene or a substituted thiophene. The polymer of the substituted thiophene is, for example, poly(3,4-ethylenedioxythiophene).

[0188]

When a method including applying a coating material for forming a top coat layer to the base material and drying or curing the coating material is adopted as a method of forming the top coat layer, as a conductive polymer to be used in the preparation of the coating material, there may be preferably used the conductive polymer in the form of being dissolved or dispersed in water (conductive polymer aqueous solution). Such conductive polymer aqueous solution may be prepared by, for example, dissolving or dispersing a conductive polymer having a hydrophilic functional group (conductive polymer that may be synthesized by an approach such as the copolymerization of monomers each having a hydrophilic functional group in a molecule thereof) in water. Examples of the hydrophilic functional group include a sulfo group, an amino group, an amide group, an imino group, a hydroxyl group, a mercapto group, a hydrazino group, a carboxyl group, a quaternary ammonium group, a sulfuric acid ester group ($-O-SO_3H$), and a phosphoric acid ester group (e.g., $-O-PO(OH)_2$). Such hydrophilic functional group may form a salt. Commercial products of a polythiophene aqueous solution are, for example, a series of products available under the product name "DENATRON" from Nagase Chemtex Corporation. A commercial product of a polyaniline sulfonic acid aqueous solution is, for example, a product available under the product name "aqua-PASS" from Mitsubishi Rayon Co., Ltd.

[0189]

The polythiophene aqueous solution is preferably used in the preparation of the coating material. The polythiophene aqueous solution is preferably a polythiophene aqueous solution containing polystyrene sulfonate (PSS) (e.g., a form in which the PSS is added as a dopant to the polythiophene). Such polythiophene aqueous solution may preferably contain the polythiophene and the PSS at a mass ratio of from 1:1 to 1:10. The total content of the polythiophene and the PSS in such polythiophene aqueous solution is preferably from 1 wt% to 5 wt%. A commercial product of such polythiophene aqueous solution is, for example, a product available under the product name "Baytron" from H.C. Starck GmbH. When the polythiophene aqueous solution containing the PSS is used as described above, the total amount of the polythiophene and the PSS is preferably from 5 parts by weight to 200 parts by weight, more preferably from 10 parts by weight to 100 parts by weight, still more preferably from 25 parts by weight to 70 parts by weight with respect to 100 parts by weight of the binder.

[0190]

The top coat layer may contain both of the conductive polymer and any other one or more kinds of antistatic components (e.g., an organic conductive substance except the conductive

polymer, an inorganic conductive substance, and an antistatic agent) as required. It is preferred that the top coat layer be substantially free of any antistatic component other than the conductive polymer. That is, it is preferred that the antistatic component in the top coat layer be formed substantially only of the conductive polymer.

[0191]

<Cross-linking Agent>

The top coat layer preferably contains the cross-linking agent. A cross-linking agent appropriately selected from cross-linking agents to be used in the cross-linking of general resins, such as a melamine-based cross-linking agent, an isocyanate-based cross-linking agent, and an epoxy-based cross-linking agent, may be used as the cross-linking agent. The use of any such cross-linking agent can achieve at least one effect out of an improvement in scratch resistance of the layer, an improvement in solvent resistance thereof, an improvement in printing adhesion thereof, and a reduction in coefficient of friction thereof (i.e., an improvement in slipperiness thereof). The cross-linking agent preferably contains the melamine-based cross-linking agent. The cross-linking agent of the top coat layer may be formed substantially only of the melamine-based cross-linking agent (melamine-based resin) (i.e., the layer may be substantially free of any cross-linking agent other than the

melamine-based cross-linking agent).

[0192]

<One preferred Mode of Top Coat Layer>

One preferred mode of the top coat layer is a mode in which when the material for the base material layer is at least one kind selected from polyimide and polyether ether ketone, the top coat layer contains a binder containing a urethane-based resin and the antistatic component. When the binder containing the urethane-based resin is adopted as a binder for the antistatic component of the top coat layer as described above, the application formability of the top coat layer on the surface of the base material layer using at least one kind selected from the polyimide and the polyether ether ketone as a material becomes excellent. Accordingly, the top coat layer can be improved in appearance, and can express an excellent antistatic property.

[0193]

In many cases, a binder containing a polyester resin is preferred as the binder for the antistatic component of the top coat layer. However, the affinity of the binder containing the polyester resin for such a specific base material layer that the material for the base material layer is at least one kind selected from the polyimide and the polyether ether ketone is

low in some cases, and hence the appearance of the top coat layer after its application and formation may deteriorate, or the layer may be unable to express an excellent antistatic property. According to a mode in which, as described above, when the material for the base material layer is at least one kind selected from the polyimide and the polyether ether ketone, the top coat layer contains the binder containing the urethane-based resin and the antistatic component, the application formability of the top coat layer on the surface of the base material layer becomes excellent. Accordingly, the top coat layer can be improved in appearance, and can express an excellent antistatic property.

[0194]

<Formation of Top Coat Layer>

The top coat layer may be suitably formed by an approach including applying, to the base material, a liquid composition (coating material for forming a top coat layer) obtained by dispersing or dissolving the above-mentioned resin component and an additive to be used as required in an appropriate solvent. For example, an approach including applying the coating material to the first surface of the base material, drying the coating material, and performing curing treatment (e.g., heat treatment or UV treatment) as required may be preferably adopted. The nonvolatile content (NV) of the coating material is preferably

5 wt% or less, more preferably from 0.05 wt% to 5 wt%, still more preferably from 0.05 wt% to 1 wt%, particularly preferably from 0.10 wt% to 1 wt%. When a top coat layer having a small thickness is formed, the NV of the coating material is set to preferably from 0.05 wt% to 0.50 wt%, more preferably from 0.10 wt% to 0.30 wt%. The use of the coating material having a low NV as described above can form a more uniform top coat layer.

[0195]

A solvent in which a top coat layer-forming component can be stably dissolved or dispersed is preferred as the solvent for forming the coating material for forming a top coat layer. Such solvent may be an organic solvent, water, or a mixed solvent thereof. The organic solvent is, for example, at least one kind selected from: esters, such as ethyl acetate; ketones, such as methyl ethyl ketone, acetone, and cyclohexanone; cyclic ethers, such as tetrahydrofuran (THF) and dioxane; aliphatic or alicyclic hydrocarbons, such as n-hexane and cyclohexane; aromatic hydrocarbons, such as toluene and xylene; aliphatic or alicyclic alcohols, such as methanol, ethanol, n-propanol, isopropanol, and cyclohexanol; and glycol ethers, such as an alkylene glycol monoalkyl ether (e.g., ethylene glycol monomethyl ether or ethylene glycol monoethyl ether) and a dialkylene glycol monoalkyl ether. Of those, water or a mixed solvent containing water as a main component (e.g., a mixed

solvent of water and ethanol) is preferred as the solvent for forming the coating material for forming a top coat layer.

[0196]

<Properties of Top Coat Layer>

The thickness of the top coat layer is preferably from 3 nm to 500 nm, more preferably from 3 nm to 100 nm, still more preferably from 3 nm to 60 nm. When the thickness of the top coat layer is excessively large, the transparency (light transmittance) of the pressure-sensitive adhesive film may be liable to reduce. When the thickness of the top coat layer is excessively small, it may become difficult to uniformly form the top coat layer. For example, a variation in thickness of the top coat layer from site to site may be large. Accordingly, unevenness may be liable to occur in the appearance of the pressure-sensitive adhesive film.

[0197]

The thickness of the top coat layer may be grasped by observing a section of the top coat layer with a transmission electron microscope (TEM). For example, a result obtained as follows may be preferably adopted as the thickness of the top coat layer: a target sample (e.g., the base material having formed thereon the top coat layer or the pressure-sensitive adhesive film including the base material) is subjected to heavy

metal dyeing treatment for the purpose of making the top coat layer clear; then, resin embedding is performed; and a section of the sample is observed with the TEM by an ultrathin sectioning method. For example, a TEM manufactured by Hitachi, Ltd. (model: "H-7650") may be used as the TEM. In Examples to be described later, the thickness (average thickness in a field of view) of the top coat layer is actually measured by: subjecting a sectional image obtained under the conditions of an acceleration voltage of 100 kV and a magnification of 60,000 to binarization treatment; and then dividing the sectional area of the top coat layer by the length of the sample in the field of view. When the top coat layer can be observed in a sufficiently clear manner without performance of heavy metal dyeing, the heavy metal dyeing treatment may be omitted. Alternatively, the thickness of the top coat layer may be determined through calculation from a calibration curve produced on the basis of a correlation between a thickness grasped with the TEM and results detected with various thickness-detecting apparatus (e.g., a surface roughness meter, an interference thickness meter, an infrared spectrometer, and various X-ray diffractometers).

[0198]

A surface resistivity measured on the surface of the top coat layer is preferably $10^{12} \Omega$ or less, more preferably from $10^4 \Omega$ to $10^{12} \Omega$, still more preferably from $10^4 \Omega$ to $10^{11} \Omega$,

particularly preferably from $5 \times 10^4 \Omega$ to $10^{10} \Omega$, most preferably from $10^4 \Omega$ to $10^9 \Omega$. A pressure-sensitive adhesive film showing such surface resistivity may be suitably utilized as a pressure-sensitive adhesive film to be used in, for example, a processing or conveying process for an article that is weak against static electricity, such as a liquid crystal cell or a semiconductor apparatus. The value of the surface resistivity may be calculated from the value of the surface resistance of the layer measured with a commercial insulation resistance-measuring apparatus under an atmosphere at 23°C and 50%RH.

[0199]

The coefficient of friction of the top coat layer is preferably 0.4 or less. When the top coat layer having a low coefficient of friction as described above is used, in the case where a load (load that may cause a scratch flaw) is applied to the top coat layer, the load is warded off along the surface of the top coat layer, and hence a frictional force due to the load can be alleviated. Thus, the cohesive failure (damage mode in which a failure occurs in the top coat layer) or interfacial failure (damage mode in which the top coat layer peels from the back surface of the base material) of the top coat layer hardly occurs. Therefore, an event in which a scratch flaw occurs in the pressure-sensitive adhesive film can be further prevented. In consideration of a balance with other characteristics (e.g.,

appearance quality and printability), the lower limit of the coefficient of friction is preferably 0.1 or more, more preferably 0.15 or more. For example, a value determined by scratching the surface of the top coat layer at a vertical load of 40 mN under a measurement environment at 23°C and 50%RH may be adopted as the coefficient of friction. The usage amount of the slip additive is desirably set so that a preferred coefficient of friction may be achieved. For example, an increase in cross-link density of the top coat layer through the addition of a cross-linking agent or the adjustment of a film formation condition is effective in adjusting the coefficient of friction.

[0200]

The back surface (surface of the top coat layer) of the pressure-sensitive adhesive film preferably has a property by which printing can be easily performed thereon with oil-based ink (e.g., by using an oil-based marking pen). Such pressure-sensitive adhesive film is suitable for the following: in, for example, a processing or conveying process for an adherend (e.g., an optical part) performed under a state in which the pressure-sensitive adhesive film is bonded thereto, the identification number or the like of the adherend serving as an object to be protected is described and displayed on the pressure-sensitive adhesive film. Therefore, a surface protective film excellent

not only in appearance quality but also in printability is preferred. For example, the pressure-sensitive adhesive film preferably has high printability with respect to oil-based ink of such a type that its solvent is an alcohol-based solvent and a pigment is incorporated thereinto. In addition, it is preferred that ink printed on the pressure-sensitive adhesive film be hardly removed by scratching or transfer (i.e., the pressure-sensitive adhesive film be excellent in printing adhesion). The pressure-sensitive adhesive film preferably has such solvent resistance that at the time of the correction or erasing of a printed character, no remarkable change in appearance of the pressure-sensitive adhesive film occurs even when the printed character is wiped off with an alcohol (e.g., ethyl alcohol).

[0201]

The top coat layer preferably contains the wax ester serving as a slip additive, and hence can achieve sufficient slipperiness (e.g., the above-mentioned preferred coefficient of friction) even in a mode in which the surface of the top coat layer is not subjected to any further release treatment (e.g., treatment in which any appropriate release treatment agent, such as a silicone-based releasing agent or a long-chain alkyl-based releasing agent, is applied thereto and dried). The mode in which the surface of the top coat layer is not subjected to any

further release treatment as described above is preferred, for example, because the whitening of the pressure-sensitive adhesive film resulting from the release treatment agent (e.g., the whitening thereof due to its storage under heated and humidified conditions) can be prevented in advance. In addition, the mode is advantageous in terms of solvent resistance.

[0202]

The pressure-sensitive adhesive film may be carried out according to a mode in which the pressure-sensitive adhesive film further includes any other layer in addition to the base material, the pressure-sensitive adhesive layer, and the top coat layer. Such "other layer" may be arranged, for example, between the first surface (back surface) of the base material and the top coat layer, or between the second surface (front surface) of the base material and the pressure-sensitive adhesive layer. The layer to be arranged between the back surface of the base material and the top coat layer may be, for example, a layer containing an antistatic component (antistatic layer). The layer to be arranged between the front surface of the base material and the pressure-sensitive adhesive layer may be, for example, an undercoat layer (anchor layer) for improving the anchoring property of the pressure-sensitive adhesive layer to the second surface, or the antistatic layer. A pressure-sensitive adhesive film having a configuration in which the

antistatic layer is arranged on the front surface of the base material, the anchor layer is arranged on the antistatic layer, and the pressure-sensitive adhesive layer is arranged thereon is permitted.

[0203]

<<<<Foldable Device and Rollable Device>>>>

The pressure-sensitive adhesive film of the present invention is excellent in bendability and transparency, and hence may be suitably arranged in, for example, a bendable device (device that can be bent) having a movable bending portion, a foldable device (device that can be folded), or a rollable device (device that can be rolled). In particular, the pressure-sensitive adhesive film of the present invention is excellent in bendability and transparency, and hence may be suitably arranged in the foldable device (device that can be folded) or the rollable device (device that can be rolled) to which it has heretofore been more difficult to apply a pressure-sensitive adhesive film than to the bendable device.

[0204]

A foldable device of the present invention includes the pressure-sensitive adhesive film of the present invention. The foldable device of the present invention may include any appropriate other member as long as the device includes the

pressure-sensitive adhesive film of the present invention.

[0205]

A rollable device of the present invention includes the pressure-sensitive adhesive film of the present invention. The rollable device of the present invention may include any appropriate other member as long as the device includes the pressure-sensitive adhesive film of the present invention.

[0206]

FIG. 1 is a schematic sectional view for illustrating a foldable device according to one embodiment of the present invention as one typical example of a usage form of the pressure-sensitive adhesive film of the present invention. In FIG. 1, a foldable device **1000** of the present invention includes a cover film **10**, a pressure-sensitive adhesive layer **20**, a polarizing plate **30**, a pressure-sensitive adhesive layer **40**, a touch sensor **50**, a pressure-sensitive adhesive layer **60**, an OLED **70**, and a pressure-sensitive adhesive film **100** of the present invention. In FIG. 1, the pressure-sensitive adhesive film **100** of the present invention includes a pressure-sensitive adhesive layer **80** and a base material layer **90**. Each of the pressure-sensitive adhesive layer **20**, the pressure-sensitive adhesive layer **40**, and the pressure-sensitive adhesive layer **60** may be a pressure-sensitive adhesive layer containing a pressure-sensitive

adhesive identical in composition to that of the pressure-sensitive adhesive layer **80** for forming the pressure-sensitive adhesive film **100** of the present invention, or may be a pressure-sensitive adhesive layer containing a pressure-sensitive adhesive different in composition from that of the pressure-sensitive adhesive layer **80**.

[0207]

The pressure-sensitive adhesive film of the present invention is excellent in bendability and transparency, and hence may be suitably arranged on, for example, the back surface (surface opposite to a display surface) of a bendable device (device that can be bent) having a movable bending portion, a foldable device (device that can be folded), or a rollable device (device that can be rolled). FIG. **1** is a view in which the pressure-sensitive adhesive film is arranged on the back surface (surface opposite to the display surface) of the foldable device (device that can be folded).

Examples

[0208]

Now, the present invention is more specifically described by way of Examples and Comparative Example. However, the present invention is by no means limited thereto. In the following description, the terms "part(s)" and "%" are by weight unless

otherwise stated.

[0209]

<tan δ >

The tan δ of a sample having a size measuring 5 mm wide by 15 mm long was measured with a viscoelasticity-measuring apparatus "RSA-G2" (manufactured by TA Instruments Japan Inc.) in a tension mode at an axial force of 100 g. In an oscillation amplitude mode, a frequency, a measurement temperature, and an immersion time were set to 1 Hz, 90°C, and 60 seconds, respectively, and a strain measurement range was set to the range of from 0.01% to 1.0%, followed by the performance of the measurement at strains in the range. The values of the tan δ at the respective strains were shown graphically, and the tan δ at a strain of 0.1% and that at a strain of 0.7% were determined from the resultant graph. With regard to the thickness of the sample that was a pressure-sensitive adhesive film, the measurement was performed by inputting only the thickness of the base material thereof excluding the thickness of the pressure-sensitive adhesive thereof on the assumption that the rigidity of the base material was so large that the influences of the pressure-sensitive adhesive on both of the storage modulus of elasticity and loss modulus of elasticity of the pressure-sensitive adhesive film were negligible.

The tan δ was determined from the following equation.

$\tan\delta$ =loss modulus of elasticity/storage modulus of elasticity

[0210]

<Bending Test>

A pressure-sensitive adhesive film in a flat state was fixed in such a manner as to be sandwiched between the silicone-treated surfaces of silicone-treated separators under a state in which the pressure-sensitive adhesive film was bent at a diameter of 6 mmφ with its pressure-sensitive adhesive layer surface facing outward as illustrated in FIG. 2, followed by its holding at 90°C for 48 hours. After that, the bending was released, and the pressure-sensitive adhesive film was left to stand at 23°C and 50%RH for 24 hours, followed by the measurement of the angle of the bent film. A case in which the film completely returned to its original state was defined as 180°, and a case in which the bent state in the initial fixation was maintained as it was defined as 0°.

[0211]

<Peeling Evaluation>

A pressure-sensitive adhesive film was bonded to a PET film having a thickness of 50 μm (manufactured by Toray Industries, Inc., S10), and the bonded product was bent so that the pressure-sensitive adhesive film faced inward as illustrated

in FIG. 3, followed by its holding at 90°C for 48 hours. After that, the fixed state was released, and the peeling of the pressure-sensitive adhesive film from the PET film was visually observed. The evaluation was performed in accordance with the following criteria.

o: No peeling from the PET film is observed.

x: Peeling from the PET film is observed.

[0212]

<Measurement of Haze and Total Light Transmittance>

The haze of a pressure-sensitive adhesive film was calculated from the following equation with a haze meter HM-150 (manufactured by Murakami Color Research Laboratory Co., Ltd.) in conformity with JIS-K-7136: haze (%) = $(T_d/T_t) \times 100$ (T_d : diffuse transmittance, T_t : total light transmittance). The total light transmittance was measured in conformity with JIS-K-7316.

[0213]

<Young's Modulus>

A sample piece was cut out into a strip shape having a width of 10 mm, and its strain-strength characteristics were measured by tensioning the strip-shaped sample piece in its lengthwise direction under an environment at a temperature of 25°C with a universal tensile and compression testing machine

(TENSILON) at a chuck-to-chuck distance of 100 mm, followed by the determination of its Young's modulus from the resultant strain-strength (S-S) curve. The measurement was performed under the conditions of a tensile rate of 200 mm/min and a chuck-to-chuck distance of 50 mm. The Young's modulus was determined from the S-S curve by a method including: producing the graph of the S-S curve; drawing a tangent (linear expression) to the graph in the displacement range of from 1 mm to 2 mm; and determining the Young's modulus from the slope of the tangent.

[0214]

<Pressure-sensitive Adhesive Strength>

A pressure-sensitive adhesive film was cut into a size measuring 25 mm wide by 150 mm long to provide an evaluation sample. Under an atmosphere at a temperature of 23°C and a humidity of 50%RH, a 2.0-kilogram roller was reciprocated once to bond the surface of the pressure-sensitive adhesive layer of the evaluation sample to a glass plate (manufactured by Matsunami Glass Ind., Ltd., product name: MICRO SLIDE GLASS S). After the bonded product had been aged under the atmosphere at a temperature of 23°C and a humidity of 50%RH for 30 minutes, the pressure-sensitive adhesive strength of the sample was measured by peeling the sample with a universal tensile tester (manufactured by Minebea Co., Ltd., product name: TCM-1kNB) at a peel angle of 180° and a tensile rate of 300 mm/min.

[0215]

<Applicability>

The number of circular uneven portions occurring in an applied top coat layer (including an antistatic layer) is counted. Two layers of an A4 size were produced, and the average number of such portions was calculated.

A case in which the number was 2 or less was judged to be satisfactory, and a case in which the number was 3 or more was judged to be unsatisfactory. The circular uneven portion is a portion where the top coat layer is reduced in thickness to serve as a defect in terms of visual appearance, and a case in which the antistatic agent was repelled, and hence could not be applied at all was judged to be "repelling".

[0216]

<Surface Resistance Value (for Example 8)>

In Example 8, the surface resistance value of a layer having formed thereon an antistatic-treated layer was measured with a volume resistance meter Model 152-1 and an attached probe 152P-2P (manufactured by Trek Japan) at a voltage of 10 V.

[0217]

<Surface Resistivity (for Examples 9 to 17 and Comparative Examples 6 to 9)>

In each of Examples 9 to 17 and Comparative Examples 6 to 9, a resistivity meter (manufactured by Mitsubishi Chemical Analytech Co., Ltd., "HIRESTA-UP MCP-HT450") was used, and its URS probe was brought into contact with the surface of a pressure-sensitive adhesive film on which no pressure-sensitive adhesive layer was arranged to measure its surface resistivity under the conditions of an applied voltage of 100 V and a voltage application time of 10 seconds.

[0218]

[Production Example 1]: Preparation of Pressure-sensitive Adhesive Composition A

63 Parts by weight of 2-ethylhexyl acrylate (2EHA), 15 parts by weight of N-vinyl-2-pyrrolidone (NVP), 9 parts by weight of methyl methacrylate (MMA), and 13 parts by weight of 2-hydroxyethyl acrylate (HEA) serving as monomer components, 0.2 part by weight of 2,2'-azobisisobutyronitrile serving as a polymerization initiator, and 133 parts by weight of ethyl acetate serving as a polymerization solvent were loaded into a separable flask, and were stirred for 1 hour while a nitrogen gas was introduced into the flask. After oxygen in the polymerization system had been removed as described above, a temperature in the system was increased to 65°C, and the mixture was subjected to a reaction for 10 hours, followed by the addition of ethyl acetate. Thus, a solution of an acrylic

polymer (a) having a solid content concentration of 30 wt% was obtained.

Next, an isocyanate-based cross-linking agent (product name: "TAKENATE D110N", manufactured by Mitsui Chemicals, Inc.) was added to the solution of the acrylic polymer (a) so that its amount became 1 part by weight with respect to 100 parts by weight of the acrylic polymer (a) (solid content) in terms of solid content. Thus, a pressure-sensitive adhesive composition A was prepared.

[0219]

[Production Example 2]: Preparation of Pressure-sensitive Adhesive Composition B

96.2 Parts by weight of 2-ethylhexyl acrylate (2EHA), 3.8 parts by weight of hydroxyethyl acrylate (HEA), 0.2 part by weight of 2,2'-azobisisobutyronitrile serving as a polymerization initiator, and 150 parts by weight of ethyl acetate were loaded into a four-necked flask including a stirring blade, a temperature gauge, a nitrogen gas-introducing tube, and a condenser, and a nitrogen gas was introduced into the flask while the mixture was gently stirred. A liquid temperature in the flask was kept at around 60°C, and a polymerization reaction was performed for 6 hours to prepare a solution (40 wt%) of an acrylic polymer (b). The acrylic polymer (b) had a weight-average molecular weight of 540,000.

Next, the solution (40 wt%) of the acrylic polymer (b) was diluted to 25 wt% with ethyl acetate, and 4 parts by weight (solid content: 4 parts by weight) of an isocyanuric body of hexamethylene diisocyanate (manufactured by Tosoh Corporation, CORONATE HX) serving as a cross-linking agent, the isocyanuric body being a trifunctional isocyanate compound, 2 parts by weight (solid content: 0.02 part by weight) of dioctyltin dilaurate (manufactured by Tokyo Fine Chemical Co., Ltd., EMBILIZER OL-1, 1 wt% ethyl acetate solution) serving as a cross-linking catalyst, and 3 parts by weight of acetylacetone were added to 400 parts by weight (solid content: 100 parts by weight) of the solution, followed by mixing and stirring. Thus, a pressure-sensitive adhesive composition B was prepared.

[0220]

[Example 1]

A commercial release liner ("DIAFOIL MRF-38", manufactured by Mitsubishi Plastics, Inc.) was prepared. The pressure-sensitive adhesive composition A was applied to one surface (release surface) of the release liner so that its thickness after drying became 25 μm , followed by drying at 130°C for 3 minutes. Thus, a 25-micrometer thick pressure-sensitive adhesive layer including an acrylic pressure-sensitive adhesive A corresponding to the pressure-sensitive adhesive composition A was formed on the release surface of the release liner.

A polyimide-based base material having a thickness of 50 μm (product name: "Kapton", manufactured by Du Pont-Toray Co., Ltd.) was prepared as a base material layer. The pressure-sensitive adhesive layer formed on the release liner was bonded to one surface of the base material layer. The release liner was left as it was on the pressure-sensitive adhesive layer to be used for the protection of the surface (pressure-sensitive adhesive layer surface) of the pressure-sensitive adhesive layer. The resultant structure was passed through a laminator at 80°C (0.3 MPa, speed: 0.5 m/min) once, and was then aged in an oven at 50°C for 1 day. Thus, a pressure-sensitive adhesive film (1) was obtained.

The results are shown in Table 1.

[0221]

[Example 2]

A pressure-sensitive adhesive film (2) was obtained in the same manner as in Example 1 except that a polyimide-based base material having a thickness of 50 μm (product name: "UPILEX-50S", manufactured by Ube Industries, Ltd.) was used as a base material layer.

The results are shown in Table 1.

[0222]

[Example 3]

A pressure-sensitive adhesive film (3) was obtained in the same manner as in Example 1 except that a polyimide-based base material having a thickness of 50 μm (product name: "PIXEO BP", manufactured by Kaneka Corporation) was used as a base material layer.

The results are shown in Table 1.

[0223]

[Example 4]

A pressure-sensitive adhesive film (4) was obtained in the same manner as in Example 1 except that a polyimide-based base material having a thickness of 50 μm (product name: "UPILEX-50RN", manufactured by Ube Industries, Ltd.) was used as a base material layer.

The results are shown in Table 1.

[0224]

[Example 5]

A pressure-sensitive adhesive film (5) was obtained in the same manner as in Example 1 except that a polyether ether ketone (PEEK)-based base material having a thickness of 50 μm (product name: "Shin-Etsu Sepla Film", highly crystalline film formed without stretching, manufactured by Shin-Etsu Polymer Co., Ltd.) was used as a base material layer.

The results are shown in Table 1.

[0225]

[Example 6]

A pressure-sensitive adhesive film (6) was obtained in the same manner as in Example 1 except that a polyimide-based base material having a thickness of 50 μm (product name: "Neopulim S100", manufactured by Mitsubishi Gas Chemical Company) was used as a base material layer.

The results are shown in Table 1.

[0226]

[Example 7]

A pressure-sensitive adhesive film (7) was obtained in the same manner as in Example 1 except that a polyether ether ketone (PEEK)-based base material having a thickness of 25 μm (product name: "EXPEEK", manufactured by Kurabo Industries Ltd.) was used as a base material layer.

The results are shown in Table 1.

[0227]

[Comparative Example 1]

A pressure-sensitive adhesive film (C1) was obtained in the same manner as in Example 1 except that a polyester-based base material having a thickness of 25 μm (product name: "Lumirror S10", manufactured by Toray Industries, Inc.) was used

as a base material layer.

The results are shown in Table 1.

[0228]

[Comparative Example 2]

A pressure-sensitive adhesive film (C2) was obtained in the same manner as in Example 1 except that a polyester-based base material having a thickness of 50 μm (product name: "Lumirror S10", manufactured by Toray Industries, Inc.) was used as a base material layer.

The results are shown in Table 1.

[0229]

[Comparative Example 3]

A pressure-sensitive adhesive film (C3) was obtained in the same manner as in Example 1 except that: the pressure-sensitive adhesive composition B was used instead of the pressure-sensitive adhesive composition A; and a polyester-based base material having a thickness of 50 μm (product name: "Lumirror S10", manufactured by Toray Industries, Inc.) was used as a base material layer.

The results are shown in Table 1.

[0230]

[Comparative Example 4]

A pressure-sensitive adhesive film (C4) was obtained in the same manner as in Example 6 except that the pressure-sensitive adhesive composition B was used instead of the pressure-sensitive adhesive composition A.

The results are shown in Table 1.

[0231]

[Comparative Example 5]

A pressure-sensitive adhesive film (C5) was obtained in the same manner as in Example 7 except that the pressure-sensitive adhesive composition B was used instead of the pressure-sensitive adhesive composition A.

The results are shown in Table 1.

[0232]

Table 1

	Base material layer	Base material layer thickness (μm)	Pressure-sensitive adhesive composition	Pressure-sensitive adhesive layer thickness (μm)	Pressure-sensitive adhesive strength (N/25 mm)	$\tan\delta$ (0.7%)	$\tan\delta$ (0.1%)	$\tan\delta$ (0.7%) - $\tan\delta$ (0.1%)	Bending test ($^\circ$)	Peeling evaluation	Young's modulus (Pa)	Total light transmittance (%)	Haze (%)
Example 1	Polyimide-based base material layer	50	A	25	21	0.07	0.03	0.04	70	o	2.5×10^9	40.1	8.5
Example 2	Polyimide-based base material layer	50	A	25	21	0.07	0.04	0.03	110	o	7.5×10^9	24.0	3.5
Example 3	Polyimide-based base material layer	50	A	25	21	0.07	0.05	0.02	115	o	4.3×10^9	61.7	11.0
Example 4	Polyimide-based base material layer	50	A	25	21	0.06	0.03	0.03	125	o	3.3×10^9	65.5	5.3
Example 5	PEEK-based base material layer	50	A	25	21	0.04	0.03	0.01	130	o	2.5×10^9	65.5	96.3
Example 6	Polyimide-based base material layer	50	A	25	21	0.05	0.04	0.01	160	o	2.3×10^9	88.3	0.2
Example 7	PEEK-based base material layer	25	A	25	21	0.05	0.02	0.03	175	o	3.3×10^9	83.4	2.6
Comparative Example 1	Polyester-based base material layer	25	A	25	21	0.16	0.10	0.06	0	o	3.3×10^9	87.5	3.5
Comparative Example 2	Polyester-based base material layer	50	A	25	21	0.14	0.08	0.06	20	o	3.3×10^9	86.7	5.7
Comparative Example 3	Polyester-based base material layer	50	B	25	0.1	-	-	-	20	x	3.3×10^9	86.7	5.7
Comparative Example 4	Polyimide-based base material layer	50	B	25	0.1	-	-	-	160	x	2.3×10^9	88.3	0.2
Comparative Example 5	PEEK-based base material layer	25	B	25	0.1	-	-	-	175	x	3.3×10^9	83.4	2.6

[0233]

[Production Example 3]: Production of Antistatic-treated Polyimide Film A

10 Parts by weight of an antistatic agent (manufactured by Solvex Inc., MICRO-SOLVER RMD-142, containing tin oxide and a polyester resin as main components) was diluted with a mixed solvent formed of 30 parts by weight of water and 70 parts by weight of methanol to prepare an antistatic agent solution. The resultant antistatic agent solution was applied onto a polyimide-based base material having a thickness of 50 μm (product name: "KAPTON", manufactured by Du Pont-Toray Co., Ltd.) serving as a base material with a Meyer bar, and an antistatic layer (thickness: 0.2 μm) was formed by drying the solution at 130°C for 1 minute to remove its solvent. Thus, an antistatic-treated polyimide film A was produced.

[0234]

[Example 8]

A pressure-sensitive adhesive film (8) was obtained in the same manner as in Example 1 except that the antistatic-treated polyimide film A was used as a base material. The film had a surface resistance value of $5 \times 10^6 \Omega$.

[0235]

[Production Example 4]: Production of Top Coat Layer-formed

Polyimide Film B

<Preparation of Coating Material B>

A dispersion liquid containing 25 wt% of a polyester resin (binder) serving as a binder (product available from Toyobo Co., Ltd., product name: "VYLONAL MD-1480" (aqueous dispersion liquid of a saturated copolymerized polyester resin); hereinafter also referred to as "binder dispersion liquid") was prepared.

In addition, an aqueous dispersion liquid of a carnauba wax (manufactured by Nippon Wax Co., Ltd., product name: "REFINED CARNAUBA WAX POWDER No. 2") (hereinafter also referred to as "slip additive dispersion liquid") was prepared as a slip additive.

Further, an aqueous solution containing 0.5 wt% of poly(3,4-dioxythiophene) (PEDOT) and 0.8 wt% of polystyrene sulfonate (number-average molecular weight: 150,000) (PSS) (product available from H.C. Starck GmbH, product name: "Baytron P"; hereinafter also referred to as "conductive polymer aqueous solution") was prepared as a conductive polymer.

100 Parts by weight of the binder dispersion liquid in terms of solid content amount, 30 parts by weight of the slip additive dispersion liquid in terms of solid content amount, 50 parts by weight of the conductive polymer aqueous solution in terms of solid content amount, and 7 parts by weight of a melamine-based cross-linking agent were added to a mixed solvent containing water and ethanol (at a weight ratio of 50:50), and

the materials were stirred for about 20 minutes to be sufficiently mixed. Thus, a coating material B having a NV of about 0.15 wt% was prepared.

<Production of Top Coat Layer-formed Polyimide Film B>

The coating material B was applied onto a polyimide-based base material having a thickness of 50 μm (product name: "KAPTON", manufactured by Du Pont-Toray Co., Ltd.) that was a base material with a bar coater, and was heated at 130°C for 2 minutes to be dried. Thus, a polyimide-based base material having, on one surface thereof, a transparent top coat layer having a thickness of 10 nm (top coat layer-formed polyimide film B) was produced.

[0236]

[Production Example 5]: Production of Top Coat Layer-formed Polyimide Film C

<Preparation of Coating Material C>

An aqueous solution containing 25 wt% of a polyester urethane resin formed of 25 mol% of ethylene glycol, 25 mol% of neopentyl glycol, 30 mol% of terephthalic acid, 10 mol% of adipic acid, and 10 mol% of tolylene diisocyanate (hereinafter also referred to as "binder dispersion liquid") was prepared as a binder.

In addition, an aqueous dispersion liquid of a carnauba wax (manufactured by Nippon Wax Co., Ltd., product name: "REFINED CARNAUBA WAX POWDER No. 2") (hereinafter also referred to as

"slip additive dispersion liquid") was prepared as a slip additive.

Further, an aqueous solution containing 0.5 wt% of poly(3,4-dioxythiophene) (PEDOT) and 0.8 wt% of polystyrene sulfonate (number-average molecular weight: 150,000) (PSS) (product available from H.C. Starck GmbH, product name: "Baytron P"; hereinafter also referred to as "conductive polymer aqueous solution") was prepared as a conductive polymer.

Further, an aqueous solution containing 10 wt% of polyethylene glycol (PEG) alkyl ether and 10 wt% of polyvinyl alcohol was prepared as a dispersant.

40 Parts by weight of the binder dispersion liquid in terms of solid content ratio, 5 parts by weight of the slip additive dispersion liquid in terms of solid content amount, 8 parts by weight of the conductive polymer aqueous solution in terms of solid content amount, 40 parts by weight of the dispersant, and 7 parts by weight of a melamine-based cross-linking agent were added to a mixed solvent containing water and ethanol (at a weight ratio of 50:50), and the materials were stirred for about 20 minutes to be sufficiently mixed. Thus, a coating material C having a NV of about 0.30 wt% was prepared.

<Production of Top Coat Layer-formed Polyimide Film C>

The coating material C was applied onto a polyimide-based base material having a thickness of 50 μm (product name: "KAPTON", manufactured by Du Pont-Toray Co., Ltd.) that was a base material

with a bar coater, and was heated at 130°C for 2 minutes to be dried. Thus, a polyimide-based base material having, on one surface thereof, a transparent top coat layer having a thickness of 50 nm (top coat layer-formed polyimide film C) was produced.

[0237]

[Example 9]

A pressure-sensitive adhesive film (9) was obtained in the same manner as in Example 1 except that the top coat layer-formed polyimide film B was used as a base material.

The results are shown in Table 2.

[0238]

[Example 10]

A pressure-sensitive adhesive film (10) was obtained in the same manner as in Example 2 except that the top coat layer-formed polyimide film B was used as a base material.

The results are shown in Table 2.

[0239]

[Example 11]

A pressure-sensitive adhesive film (11) was obtained in the same manner as in Example 4 except that the top coat layer-formed polyimide film B was used as a base material.

The results are shown in Table 2.

[0240]

[Example 12]

A pressure-sensitive adhesive film (12) was obtained in the same manner as in Example 7 except that the top coat layer-formed polyimide film B was used as a base material.

The results are shown in Table 2.

[0241]

[Example 13]

A pressure-sensitive adhesive film (13) was obtained in the same manner as in Example 1 except that the top coat layer-formed polyimide film C was used as a base material.

The results are shown in Table 2.

[0242]

[Example 14]

A pressure-sensitive adhesive film (14) was obtained in the same manner as in Example 2 except that the top coat layer-formed polyimide film C was used as a base material.

The results are shown in Table 2.

[0243]

[Example 15]

A pressure-sensitive adhesive film (15) was obtained in

the same manner as in Example 3 except that the top coat layer-formed polyimide film C was used as a base material.

The results are shown in Table 2.

[0244]

[Example 16]

A pressure-sensitive adhesive film (16) was obtained in the same manner as in Example 4 except that the top coat layer-formed polyimide film C was used as a base material.

The results are shown in Table 2.

[0245]

[Example 17]

A pressure-sensitive adhesive film (17) was obtained in the same manner as in Example 7 except that the top coat layer-formed polyimide film C was used as a base material.

The results are shown in Table 2.

[0246]

[Comparative Example 6]

A pressure-sensitive adhesive film (C6) was obtained in the same manner as in Comparative Example 1 except that the top coat layer-formed polyimide film B was used as a base material.

The results are shown in Table 2.

[0247]

[Comparative Example 7]

A pressure-sensitive adhesive film (C7) was obtained in the same manner as in Comparative Example 2 except that the top coat layer-formed polyimide film B was used as a base material.

The results are shown in Table 2.

[0248]

[Comparative Example 8]

A pressure-sensitive adhesive film (C8) was obtained in the same manner as in Comparative Example 1 except that the top coat layer-formed polyimide film C was used as a base material.

The results are shown in Table 2.

[0249]

[Comparative Example 9]

A pressure-sensitive adhesive film (C9) was obtained in the same manner as in Comparative Example 2 except that the top coat layer-formed polyimide film C was used as a base material.

The results are shown in Table 2.

Table 2

	Base material layer	Base material layer thickness (μm)	Coating material for forming top coat layer	Top coat layer thickness (nm)	$\tan\delta$ (0.7%)	$\tan\delta$ (0.1%)	$\tan\delta$ (0.7%) - $\tan\delta$ (0.1%)	Bending test ($^{\circ}$)	Applicability	Surface resistivity (Ω)
Example 9	Polyimide-based base material layer	50	B	10	0.07	0.03	0.04	70	8.5 uneven portions Unsatisfactory	1.42×10^6
Example 10	Polyimide-based base material layer	50	B	10	0.07	0.04	0.03	110	15 uneven portions Unsatisfactory	2.84×10^6
Example 11	Polyimide-based base material layer	50	B	10	0.06	0.03	0.03	125	8.5 uneven portions Unsatisfactory	2.35×10^6
Example 12	PEEK-based base material layer	25	B	10	0.05	0.02	0.03	175	5 uneven portions Unsatisfactory	1.52×10^6
Example 13	Polyimide-based base material layer	50	C	50	0.07	0.03	0.04	70	1 uneven portion Satisfactory	5.73×10^7
Example 14	Polyimide-based base material layer	50	C	50	0.07	0.04	0.03	110	0 uneven portions Satisfactory	1.22×10^7
Example 15	Polyimide-based base material layer	50	C	50	0.07	0.05	0.02	115	0 uneven portions Satisfactory	1.26×10^7
Example 16	Polyimide-based base material layer	50	C	50	0.06	0.03	0.03	125	0 uneven portions Satisfactory	6.59×10^7
Example 17	PEEK-based base material layer	25	C	50	0.05	0.02	0.03	175	0 uneven portions Satisfactory	1.53×10^7
Comparative Example 6	Polyester-based base material layer	25	B	10	0.16	0.10	0.06	0	0 uneven portions Satisfactory	1.06×10^6
Comparative Example 7	Polyester-based base material layer	50	B	10	0.14	0.08	0.06	20	0 uneven portions Satisfactory	1.68×10^6
Comparative Example 8	Polyester-based base material layer	25	C	50	0.16	0.10	0.06	0	0 uneven portions Satisfactory	2.77×10^7
Comparative Example 9	Polyester-based base material layer	50	C	50	0.14	0.08	0.06	20	0 uneven portions Satisfactory	2.37×10^7

Industrial Applicability

[0251]

The pressure-sensitive adhesive film of the present invention is excellent in bendability and transparency, and hence may be suitably arranged in, for example, a bendable device (device that can be bent) having a movable bending portion, a foldable device (device that can be folded), or a rollable device (device that can be rolled).

Reference Signs List

[0252]

- 1000 foldable device
- 100 pressure-sensitive adhesive film
- 10 cover film
- 20 pressure-sensitive adhesive layer
- 30 polarizing plate
- 40 pressure-sensitive adhesive layer
- 50 touch sensor
- 60 pressure-sensitive adhesive layer
- 70 OLED
- 80 pressure-sensitive adhesive layer
- 90 base material layer
- 1 6 mm Φ glass rod
- 2 silicone-treated separator
- 3 adhesive layer

4 fixing glass

5 PET film

Claims

[Claim 1]

A pressure-sensitive adhesive film, comprising:
a base material layer; and
a pressure-sensitive adhesive layer,
wherein the pressure-sensitive adhesive film has a $\tan\delta(0.7\%)$ at a strain of 0.7% of 0.1 or less, which is measured in a tension mode of a viscoelasticity-measuring apparatus.

[Claim 2]

A pressure-sensitive adhesive film, comprising:
a base material layer; and
a pressure-sensitive adhesive layer,
wherein a difference ($\tan\delta(0.7\%) - \tan\delta(0.1\%)$) between a $\tan\delta(0.7\%)$ of the pressure-sensitive adhesive film at a strain of 0.7% and a $\tan\delta(0.1\%)$ thereof at a strain of 0.1%, which are measured in a tension mode of a viscoelasticity-measuring apparatus, is 0.05 or less.

[Claim 3]

The pressure-sensitive adhesive film according to claim 1 or 2, wherein the pressure-sensitive adhesive film has a bending angle of from 60° to 180° after the pressure-sensitive adhesive film has been bent at a diameter of 6 mm ϕ and held at 90°C for 48 hours, and then the bending has been released, and the

pressure-sensitive adhesive film has been left to stand at 23°C and 50%RH for 24 hours.

[Claim 4]

The pressure-sensitive adhesive film according to any one of claims 1 to 3, further comprising a top coat layer on a surface of the base material layer opposite to a surface thereof having the pressure-sensitive adhesive layer.

[Claim 5]

The pressure-sensitive adhesive film according to claim 4, wherein the top coat layer contains a binder containing at least one kind selected from a polyester resin and a urethane-based resin.

[Claim 6]

The pressure-sensitive adhesive film according to claim 5, wherein the binder contains the urethane-based resin.

[Claim 7]

The pressure-sensitive adhesive film according to any one of claims 4 to 6, wherein the top coat layer contains an antistatic component.

[Claim 8]

The pressure-sensitive adhesive film according to any one of claims 1 to 7, wherein the base material layer has a Young's modulus of 6.0×10^7 Pa or more at 23°C.

[Claim 9]

The pressure-sensitive adhesive film according to claim 8, wherein a material for the base material layer is at least one kind selected from polyimide and polyether ether ketone.

[Claim 10]

The pressure-sensitive adhesive film according to any one of claims 1 to 3, further comprising a top coat layer on a surface of the base material layer opposite to a surface thereof having the pressure-sensitive adhesive layer,

wherein the top coat layer contains a binder containing a urethane-based resin and an antistatic component, and

wherein a material for the base material layer is at least one kind selected from polyimide and polyether ether ketone.

[Claim 11]

The pressure-sensitive adhesive film according to any one of claims 1 to 10, wherein the pressure-sensitive adhesive film has a total light transmittance of 20% or more.

[Claim 12]

The pressure-sensitive adhesive film according to any one of claims 1 to 11, wherein the pressure-sensitive adhesive film has a haze of 15% or less.

[Claim 13]

The pressure-sensitive adhesive film according to any one of claims 1 to 12, wherein the pressure-sensitive adhesive layer has a pressure-sensitive adhesive strength to a SUS plate of 1 N/25 mm or more at 23°C, a tensile rate of 300 mm/min, and a peel angle of 180°.

[Claim 14]

The pressure-sensitive adhesive film according to any one of claims 1 to 13, wherein the pressure-sensitive adhesive layer contains an acrylic pressure-sensitive adhesive.

[Claim 15]

The pressure-sensitive adhesive film according to any one of claims 1 to 14, wherein the pressure-sensitive adhesive film is bonded to a foldable member.

[Claim 16]

The pressure-sensitive adhesive film according to claim 15, wherein the foldable member is an OLED.

[Claim 17]

The pressure-sensitive adhesive film according to any one of claims 1 to 16, wherein the pressure-sensitive adhesive film is bonded to a rollable member.

[Claim 18]

The pressure-sensitive adhesive film according to claim 17, wherein the rollable member is an OLED.

[Claim 19]

A foldable device, comprising the pressure-sensitive adhesive film of any one of claims 1 to 14.

[Claim 20]

A rollable device, comprising the pressure-sensitive adhesive film of any one of claims 1 to 14.