

LAMINATE

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0001]

The present invention relates to a laminate, in particular, a laminate having a decorative film.

2. Description of the Related Art

[0002]

Decorative films such as metallic films are used to provide design quality, etc., in various applications including cover materials for vehicles and portable electronic devices such as smartphones, table PCs and laptop PCs. The surface (decorative face) of such a decorative film has a design including a color, color tone and pattern. For instance, some recently proposed decorative films are highly functional, such as having electromagnetic wave transmission in addition to metallic luster as the design. A conventional art document teaching this type of conventional art is Japanese Patent Application Publication No. 2018-69462.

[0003]

Meanwhile, as means of bonding films and components, pressure-sensitive adhesive (PSA) has been widely used in various industrial fields. PSA exists as a soft solid (a viscoelastic material) in a room temperature range and has a property to adhere easily to an adherend with some pressure applied. In addition to the adhesive property, it may have one, two or more properties suited for various applications. For instance, a PSA used for optical applications may have transparency and excellent visibility through the PSA in addition to the adhesiveness to components. Conventional art documents teaching this type of conventional art include Japanese Patents No. 4673344 and No. 4805999. Japanese Patent No. 6251801 is a conventional art document disclosing an anti-shatter PSA sheet applied to a cover glass of an electrostatic capacitive touch panel.

SUMMARY OF THE INVENTION

[0004]

Such a conventional decorative film is used by placing its backside to a substrate

surface and the decorative face (surface) of the decorative films is typically on the outermost surface. In such an embodiment, the decorative film needs to have a certain level of durability against external force or in use environment. As an alternative means, the decorative film surface may be provided with a protective layer to increase the durability; however, it is likely to degrade the design quality of the decorative film and there are disadvantages to forming such protective layers as it leads to increases in number of steps, thickness and cost.

[0005]

The present invention has been made in view of these circumstances with an objective to provide a novel laminate that does not impair the visibility of decorative film's design.

[0006]

This Description provides a laminate having a transparent member, a PSA layer and a decorative film arranged in this order. With this laminate, the design (encompassing a color, color tone, pattern, and character information such as a logo mark; the same applies hereinafter) of the decorative film surface can be observed through the transparent member and PSA layer. With the presence of the decorative film, etc., the laminate at large can have concealing properties (content-concealing properties when the transparent member side is considered to be on the outside).

[0007]

In some preferable embodiments, the laminate has a visible light transmittance below 10 % in the layering direction (build direction or thickness direction) of the transparent member, the PSA layer and the decorative film. The laminate thus configured can bring out the design quality of the decorative film while exhibiting good concealing properties. For instance, when the transparent member of the laminate is used as a case for a structure such as a portable electronic device, the content inside the structure is concealed while, on the outer surface, the design of the decorative film can be observed through the transparent member.

[0008]

In some preferable embodiments, the PSA layer surface has an arithmetic mean roughness Ra of 70 nm or less and a maximum height Rz of 600 nm or less. With the use of the PSA layer with such high surface smoothness, the design of the decorative film surface can be better observed through the PSA layer.

[0009]

In some preferable embodiments, the PSA layer has a total light transmittance of 85 % or higher and a haze value of 1 % or lower in its layering direction (thickness direction). With the PSA layer satisfying these properties, the design of the decorative film surface can be better observed through the PSA layer. In some embodiments, the laminate structure of the transparent member and the PSA layer has, in the layering direction thereof, a total light transmittance of 85 % or higher and a haze value of 1 % or lower. With the transparent member and the PSA layer satisfying these properties, the design of the decorative film surface can be better observed through the transparent member and the PSA layer.

[0010]

In some preferable embodiments, the PSA layer has a storage modulus of 4×10^4 Pa or greater at 25 °C. The PSA layer having such a 25°C storage modulus tends to have preferable heat resistance and is likely to exhibit good adhesive properties such as deformation resistance.

[0011]

In some preferable embodiments, the PSA layer is bonded to the transparent member with a 180° peel strength greater than 7 N/20mm. When the transparent member and PSA layer are tightly bonded, the laminate can exhibit great endurance against impact, etc.

[0012]

In some preferable embodiments, the PSA layer is an acrylic PSA layer. The acrylic PSA is likely to combine transparency, adhesive properties and viscoelastic properties because it can bring about target adhesive properties and viscoelastic properties without or with limited usage of additives such as softeners that may reduce the transparency. For instance, acrylic PSA tends to have superior discoloration resistance to rubber-based PSA and is advantageous in view of maintaining the transparency for a long period.

[0013]

In some preferable embodiments, the PSA layer has an elastic modulus of 3.0 MPa or greater, determined by the tensile test described below. By satisfying this property, the PSA layer can provide high deformation resistance.

[Tensile test]

The PSA layer is irradiated with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm² and allowed to age at 50 °C for 48 hours. Subsequently, the PSA layer is cut to a 10 mm wide, 150 mm long size to prepare a test piece. In an environment at 23 °C and 50 %RH, using a tensile tester, a tensile test is carried out on the test piece at a chuck distance of 120 mm at a tensile speed of 50 mm/min to obtain a stress-displacement curve. From the initial slope, the elastic modulus (MPa) is determined.

[0014]

In some preferable embodiments, the PSA layer has an impact strength of 2.0 J/10mm² or greater, determined by the shear impact test described below. By satisfying this property, the PSA layer may provide high impact toughness. For instance, the PSA layer satisfying the elastic modulus by the tensile test and the impact strength properties can form a highly deformation-resistant and highly impact-resistant bonding; and therefore, the laminate having the PSA layer can also have excellent deformation resistance and impact resistance.

[Shear impact test]

The shear impact test is carried out using a pendulum-type shear impact tester for adhesive bonds based on JIS K 6855. A measurement sample is obtained by applying the first face of a 10 mm square piece of the PSA layer to the center of a 25 mm square chemically-reinforced glass plate (1.7 mm thick) and applying the second face thereof to the center of a 40 mm square stainless steel plate (SUS304BA plate); press-bonding them under a 5 N load for 10 seconds; autoclaving the resultant (50 °C, 0.5 MPa, 15 min); irradiating it with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm²; and then allowing it to age at 50 °C for 48 hours.

The measurement sample is fastened with the stainless steel plate down. In an environment at 23 °C and 50 %RH, the outer circumference of the glass plate is struck with a hammer at a hammer energy of 2.75 J at a hammer speed of 3.5 m/s and the energy (J) absorbed during this is measured to determine the impact strength (J/10mm²).

[0015]

In some preferable embodiments, the PSA layer comprises a polymer (A) and a photoreactive monomer (B). The photoreactive monomer (B) comprises a compound B1 having a ring structure and two or more ethylenically unsaturated groups per molecule. The compound B1 more preferably has a molecular weight of 100 g/mol or higher per

ethylenically unsaturated group. Thus, the laminate having the PSA layer can also have excellent deformation resistance and impact resistance.

[0016]

In some preferable embodiments, the decorative film has a substrate layer and a decoration layer covering at least part of at least one face of the substrate layer. The decoration layer has a thickness in the range between 1 nm and 1000 nm. When the decorative film having such a thin decoration layer is included in the laminate disclosed herein, the transparent member and PSA layer protect the decorative film surface, thereby preventing its deterioration such as discoloration and peeling.

[0017]

In some preferable embodiments, the decoration layer has a sheet resistance of 100 Ω /sq or greater. The decorative film having such a decoration layer can transmit radio waves. Thus, it can be preferably used in various applications requiring radio wave transmission, for instance, portable electronic devices.

[0018]

In some embodiments, the transparent member has a rectilinear bend or a curvilinear arc in an arbitrary cross section in parallel with the layering direction of the laminate. The PSA layer and the decorative film are placed where the bend or the arc of the transparent member exists. According to the art disclosed herein, in an embodiment having a transparent member having a bend or arc as described above, the design of the decorative film surface can be well observed through the transparent member and PSA layer.

[0019]

The laminate according to some embodiments has one, two or more colored layers. Each of the colored layers is placed at any location among the following: between the transparent member and the PSA layer, between the PSA layer and the decorative film, and on the reverse side of the PSA layer side of the decorative film. With such a laminate structure, because of the presence of the colored layer(s), higher concealing properties can be obtained.

[0020]

The laminate according to some embodiments can be preferably used in a portable electronic device. For instance, when the transparent member disclosed herein is used as a transparent (encompassing semi-transparent) case, it is possible to build a

structure in which the decorative film is fixed to the inside of the case. With respect to such a structure, while the design of the decorative film can be observed from the outside, because it may have content-concealing properties, it can be particularly suitable as an exterior structure such as a case. Furthermore, depending on the selected decorative film, it may transmit radio waves; and therefore, it can be preferably used as a laminate for use in a portable electronic device.

BRIEF DESCRIPTION OF THE DRAWINGS

[0021]

Fig. 1 shows a schematic cross-sectional diagram of the laminate according to an embodiment.

Fig. 2 shows a schematic cross-sectional diagram of the laminate according to another embodiment.

Fig. 3 shows a schematic cross-sectional diagram of the laminate according to another embodiment.

Fig. 4 shows a schematic cross-sectional diagram of the laminate according to another embodiment.

DETAILED DESCRIPTION OF THE INVENTION

[0022]

Preferred embodiments of the present invention are described below. Matters necessary to practice this invention other than those specifically referred to in this description can be understood by a person skilled in the art based on the disclosure about implementing the invention in this description and common general knowledge at the time of application. The present invention can be practiced based on the contents disclosed in this description and common technical knowledge in the subject field. In the drawings referenced below, a common reference numeral may be assigned to members or sites producing the same effects, and duplicated descriptions are sometimes omitted or simplified. The embodiments described in the drawings are schematized for clear illustration of the present invention, and do not necessarily represent the accurate size or reduction scale of an actual product provided.

[0023]

As used herein, the term "PSA" refers to, as described earlier, a material that

exists as a soft solid (a viscoelastic material) in a room temperature range and has a property to adhere easily to an adherend with some pressure applied. As defined in "Adhesion : Fundamental and Practice" by C. A. Dahlquist (McLaren & Sons (1966), P. 143), PSA referred to herein may be a material that has a property satisfying complex tensile modulus $E^* (1\text{Hz}) < 10^7 \text{ dyne/cm}^2$ (typically, a material that exhibits the described characteristics at 25 °C).

[0024]

As used herein, the term "acrylic polymer" refers to a polymer derived from a starting monomer mixture including more than 50 % acrylic monomer by weight, which is also called an acrylic polymer. The acrylic monomer refers to a monomer having at least one (meth)acryloyl group per molecule. As used herein, the term "(meth)acryloyl" comprehensively refers to acryloyl and methacryloyl. Similarly, the term "(meth)acrylate" comprehensively refers to acrylate and methacrylate, and the term "(meth)acryl" comprehensively refers to acryl and methacryl.

As used herein, the "mass" and the "weight" are considered synonymous.

[0025]

As used herein, the "photoreactive monomer" is a compound having, per molecule, at least one functional group (photoreactive functional group) that can undergo reaction when irradiated; in typical, a compound having at least one ethylenically unsaturated group per molecule as the photoreactive functional group. As long as it is reactive as a monomer, the photoreactive monomer here can be, for instance, an oligomer, polymer or the like (e.g. a polymer having at least one ethylenically unsaturated group per molecule).

[0026]

< Examples of constitution of laminate >

Fig. 1 shows a constitutional example of the laminate. Laminate 1 has a transparent member 10, PSA layer 20 and decorative film 30 placed in this order. PSA layer 20 has a first adhesive face 20a, and a second adhesive face 20b on the reverse side of the first adhesive face 20a. Transparent member 10 and PSA layer 20 are bonded together. In particular, the PSA layer side surface (second face) 10b of transparent member 10 is bonded to the first adhesive face 20a of PSA layer 20. The outer face of laminate 1 is formed with the reverse face (first face) 10a of PSA layer side surface 10b of transparent member 10. PSA layer 20 is also bonded with decorative film 30. In

particular, the second adhesive face 20b of PSA layer 20 is bonded to one face (first face) 30a of decorative film 30. In this embodiment, the surface 30a of the decorative film is a decorative face.

[0027]

Fig. 2 schematically illustrates the constitution of the laminate according to another embodiment. Having a colored layer 40 placed between transparent member 10 and PSA layer 20, laminate 2 shown in Fig. 2 is different from laminate 1 shown in Fig. 1. In this embodiment, colored layer 40 is partially formed on the second face 10b of transparent member 10. Thus, by as much as of its thickness, colored layer 40 protrudes above the second face 10b of transparent member 10, and the PSA layer 20 side of transparent member 10 including colored layer 40 has contours (protrusions) as a whole. The first adhesive face 20a of PSA layer 20 conforms to the contoured face with tight bonding. As other features are basically the same as the constitution shown in Fig. 1, redundant details are omitted here.

[0028]

Fig. 3 schematically illustrates the constitution of the laminate according to yet another embodiment. Having a colored layer 50 below decorative film 30 (on the reverse side of the PSA layer 20 side), laminate 3 shown in Fig. 3 is different from laminate 2 shown in Fig. 2. In other words, laminate 3 has transparent member 10, PSA layer 20, decorative film 30 and colored layer 50 in this order. Similar to laminate 2, in laminate 3, colored layer (partially-disposed colored layer) 40 is also placed between transparent member 10 and PSA layer 20. In this embodiment, colored layer 50 is placed on the second face 30b (the reverse face of the first face 30a on PSA layer 20 side) of decorative film 30. In particular, colored layer 50 is placed entirely on the second face 30b of decorative film 30. Colored layer 50 in this embodiment is a black-colored layer and laminate 3 has concealing properties in its layering direction. As other features are basically the same as the constitution shown in Fig. 2, redundant details are omitted here.

[0029]

Fig. 4 schematically illustrates the constitution of the laminate according to yet another embodiment. Having a second PSA layer 60 below decorative film 30 (on the reverse side of the first PSA layer 20 side) and further having a colored layer 50 below the second PSA layer 60 (on the reverse side of the decorative film 30 side), laminate 4 shown

in Fig. 4 is different from laminate 3 shown in Fig. 3. In other words, laminate 4 has transparent member 10, first PSA layer 20, decorative film 30, second PSA layer 60 and colored layer 50 in this order. Similar to laminate 3, in laminate 4, colored layer (partially-disposed colored layer) 40 is also placed between transparent member 10 and PSA layer 20. In this embodiment, the first adhesive face 60a of second PSA layer 60 is bonded to the second face 30b of decorative film 30, and the second adhesive face 60b of second PSA layer 60 is bonded to colored layer 50. The second PSA layer 60 and colored layer 50 can be an adhesively single-faced, substrate-bearing PSA sheet. The thickness of second PSA layer 60 is larger than that of first PSA layer 20. Similar to the constitution shown in Fig. 3, colored layer 50 is placed entirely on the second face 60b of second PSA layer 60. Colored layer 50 in this embodiment is a black-colored layer and laminate 4 has concealing properties in its layering direction. As other features are basically the same as the constitution shown in Fig. 3, redundant details are omitted here.

[0030]

It is noted that while colored layer 40 is partially provided on the second face 10b of transparent member 10 in the constitutions shown in Figs. 2 to 4, it is not limited to this. The partially-disposed colored layer can also be formed in a depression formed in the second face of the transparent member. By this, the colored layer partially disposed on the transparent member's second face can be made to not protrude above the second face. Alternatively, the partially-disposed colored layer can be partially formed on the first adhesive face of the PSA layer. Such a colored layer can be placed on the second face of the PSA layer.

[0031]

In the constitutions shown in Figs. 3 and 4, colored layer 50 was placed below the decorative film (on the reverse side of the PSA layer 20 side). For instance, in laminate 4 shown in Fig. 4, however, such a colored layer can also be placed between decorative film 30 and second PSA layer 60. The colored layer can also be placed as a colored PSA layer below the decorative film (on the reverse side of the PSA layer 20 side).

[0032]

Between the transparent member and PSA layer or between the PSA layer and decorative film, additional layers such as a primer layer and easy adhesion layer can be included, or an optional layer such as a layer containing a colorant while having transparency can be provided to at least part of the interface (entirely or partially to the

interface). The reverse side (outside) of the PSA layer side of the transparent member can be provided with a protective layer such as a hard coat layer.

[0033]

The PSA layer can be an inner-substrate-bearing PSA sheet having an enclosed (embedded) non-separable substrate. As the substrate, plastic film, paper, nonwoven fabric and the like can be used. The examples in Figs. 1 to 4 illustrate embodiments having monolayer (first and second) PSA layers 20 and 60; however, the constitution of PSA layer 10 is not limited to these. For instance, the PSA layer can include two or more sub-PSA layers formed of the same or different PSA. From the standpoint of the productivity and transparency, a monolayer PSA layer is preferable.

[0034]

<Properties of laminate>

The laminate disclosed herein has a visible light transmittance below 30 % in the layering direction of the transparent member, PSA layer and decorative film. The laminate thus configured can bring out the design quality of the decorative film while having good concealing properties. For instance, when the transparent member of the laminate is used as a case for a structure such as a portable electronic device, the content inside the structure is concealed while, on the outer surface, the design of the decorative film can be observed through the transparent member and PSA layer.

[0035]

From the standpoint of the concealing properties and light-blocking properties, the laminate has a visible light transmittance of possibly below 20 %, preferably below 10 %, also possibly 7.0 % or lower, for instance, 3.0 % or lower, or even 1.0 % or lower (possibly essentially 0 % to 1.0 %). The laminate's visible light transmittance can be adjusted through the decorative film's selected transparency; placement and thickness of one, two or more colored layers; selected colorant and concentration in the colored layer, etc. The laminate's visible light transmittance is determined by measuring the transmittance of the visible light range (380 nm to 780 nm) by a spectrophotometer. The same method is used for measurements in the working examples described later.

[0036]

<Transparent member>

The transparent member disclosed herein is not particularly limited as long as it has transparency. Examples of the material forming the transparent member include

glass such as an alkaline glass or non-alkaline glass; and resin materials such as acrylic resin, ABS resin, polycarbonate resin, transparent polyimide, polyester resin such as polyethylene terephthalate (PET), and polystyrene resin. For the transparent member, solely one species or a combination of two or more species as a laminate, etc., can be used.

[0037]

In some embodiments, the transparent member has a total light transmittance of, for instance, about 50 % or higher, or suitably about 70 % or higher. From the standpoint of the visibility of the sort of decorative film through the transparent member, in some preferable embodiments, the total light transmittance of the transparent member is about 85 % or higher, or more preferably about 90 % or higher. The maximum total light transmittance is theoretically the value obtained by subtracting from 100 % the optical loss (Fresnel loss) due to reflection occurring at the interface with air. For practical use, it can be about 95 % or lower, or even about 94 % or lower (e.g. 93 % or lower).

[0038]

(Haze value)

In some embodiments, the transparent member has a haze value of, for instance, about 10 % or lower, suitably about 3 % or lower. From the standpoint of the visibility through the transparent member, in some preferable embodiments, the transparent member has a haze value of about 1 % or lower, more preferably about 0.8 % or lower, or yet more preferably 0.5 % or lower. The minimum haze value is theoretically 0 % and can be above about 0.0 % for practical use. The term “haze value” refers to the ratio of scattered light transmitted to total light transmitted when visible light is irradiated on the measurement subject. It is also called a fog value. The haze value can be expressed by the following equation:

$$Th (\%) = Td/Tt \times 100$$

In the equation, Th is the haze value (%), Td the diffuse transmittance, and Tt the total light transmittance.

[0039]

The transparent member's total light transmittance and haze value can be determined, using a haze meter. As the haze meter, it is possible to use system name HM-150N available from Murakami Color Research Laboratory Co., Ltd. or a comparable system.

[0040]

The transparent member having such total light transmittance and haze value can be a colored or colorless transparent member. As used herein, the term “transparent” is used, conceptually encompassing semi-transparent.

[0041]

While the transparent member can be flat, it may also have contours such as print, engraving and the like on the face to which the PSA layer is applied (or the PSA layer-bonding face); or the transparent member may also have a 3D shape as a whole. The PSA layer disclosed herein may also have excellent contour-following properties. Thus, it may also tightly adhere to the contoured transparent member surface. The 3D-shaped transparent member may have a rectilinear bend or curvilinear arc in a cross section in the thickness direction. In the transparent member, the PSA layer side face may have a shape bending or arching in an arbitrary direction or in two directions including the arbitrary direction and another direction that intersects (e.g. orthogonally intersects) the first direction. In other words, the PSA layer side face of the transparent member may have a 2D contour or 3D contour.

[0042]

In an embodiment comprising a transparent member having a 2D or 3D contour as described above, the PSA layer and decorative film layered on the transparent member as well as any additional layer such as a colored layer, if necessary, can be placed only at a flat area of the transparent member, or they can be placed not only at the flat area, but also at the contour (in particular, at a bend or arc). According to such an embodiment, even at the contour of the transparent member, the design on the decorative film surface can be observed through the transparent member and PSA layer. The laminate may also have a concealing effect even at the contour of the transparent member.

[0043]

The transparent member's thickness is suitably selected in accordance with the purpose and usage and is not particularly limited. The transparent member has a thickness of, for instance, 0.01 mm or greater, or suitably 0.05 mm or greater. From the standpoint of the strength, etc, it is preferably 0.1 mm or greater, possibly 0.5 mm or greater, 1 mm or greater, or even 3 mm or greater. The transparent member has a thickness of suitably about 30 mm or less, preferably about 10 mm or less, possibly about 7 mm or less, about 5 mm or less, about 2 mm or less, or even below 1 mm (e.g. below 0.3

mm).

[0044]

<PSA layer>

In the art disclosed herein, the type of PSA forming the PSA layer (encompassing the first and second adhesive layers; the same applies hereinafter, unless otherwise noted) is not particularly limited. For example, the PSA layer may be constituted, comprising one, two or more species of PSA selected among various known species of PSA, such as an acrylic PSA, rubber-based PSA (natural rubber-based, synthetic rubber-based, their mixture-based, etc.), silicone-based PSA, polyester-based PSA, urethane-based PSA, polyether-based PSA, polyamide-based PSA, fluorine-based PSA, etc. Here, the acrylic PSA refers to a PSA comprising an acrylic polymer as the base polymer (the primary component among polymers, i.e., a component accounting for more than 50 % by mass). The same applies to the rubber-based PSA and other PSA.

[0045]

(Polymer (A))

In some embodiments, the PSA layer comprises a polymer (A). Examples of the material that can be used as the polymer (A) include polymers showing viscoelasticity in a room temperature range, such as acrylic polymers, rubber-based polymers, polyester-based polymers, urethane-based polymers, polyether-based polymers, silicone-based polymers, polyamide-based polymers, and fluoropolymers known in the PSA field. Of these, solely one species or a combination of two or more species can be used.

[0046]

From the standpoint of the adhesive properties such as impact strength, the weight ratio of polymer (A) in the total weight of the PSA layer is suitably 40 % by weight or higher, preferably 50 % by weight or higher, more preferably 60 % by weight or higher, yet more preferably 70 % by weight or higher, possibly about 80 % by weight or higher, about 90 % by weight or higher, or even about 97 % by weight or higher (e.g. about 99 % by weight or higher). The PSA with a high polymer (A) content also tends to bring about excellent transparency. The weight ratio of polymer (A) in the weight of the entire PSA layer is typically below 100 % by weight. From the standpoint of readily adjusting the balance of properties, it is advantageously 95 % by weight or lower, preferably 92 % by weight or lower, possibly 90 % by weight or lower, or even 87 % by weight or lower.

[0047]

A favorable example of polymer (A) is an acrylic polymer. The PSA layer in the art disclosed herein can be an acrylic PSA layer comprising an acrylic polymer as the base polymer (primary component among polymers, i.e., a component accounting for more than 50 % by weight). The acrylic PSA is preferable from the standpoint of the transparency, weatherability, etc., and is likely to bring about viscoelastic properties with excellent impact strength without heavily relying on additives such as softener. The acrylic polymer (or “acrylic polymer (A)” hereinafter) as the polymer (A) is preferably formed from monomers comprising at least 40 % (by weight) alkyl (meth)acrylate having a linear or branched alkyl group with 1 up to 20 carbon atoms at an ester terminus. Hereinafter, an alkyl (meth)acrylate having, at the ester terminus, an alkyl group with X number up to Y number of carbon atoms may be referred to as an “C_{X-Y} alkyl (meth)acrylate.”

[0048]

In some embodiments, for easy balancing of properties, the ratio of C₁₋₂₀ alkyl (meth)acrylate in the entire monomers of acrylic polymer (A) is suitably above 40 % by weight, for instance, possibly 45 % by weight or higher, 50 % by weight or higher, 55 % by weight or higher, or even 60 % by weight or higher. The ratio of C₁₋₂₀ alkyl (meth)acrylate in the monomers can be 100 % by weight; however, because of the ease of balancing properties, it is suitably 98 % by weight or lower, for instance, possibly 95 % by weight or lower, or even 90 % by weight or lower. In some embodiments, from the standpoint of increasing the PSA layer's cohesion, the ratio of C₁₋₂₀ alkyl (meth)acrylate in the entire monomers of acrylic polymer (A) can be, for instance, 85 % by weight or lower, 80 % by weight or lower, 75 % by weight or lower, 70 % by weight or lower, 65 % by weight or lower, or even 60 % by weight or lower.

[0049]

Non-limiting specific examples of the C₁₋₂₀ alkyl (meth)acrylate include methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, s-butyl (meth)acrylate, t-butyl (meth)acrylate, pentyl (meth)acrylate, isopentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, octyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, isooctyl (meth)acrylate, nonyl (meth)acrylate, isononyl (meth)acrylate, decyl (meth)acrylate, isodecyl (meth)acrylate, undecyl (meth)acrylate, dodecyl (meth)acrylate, tridecyl (meth)acrylate, tetradecyl (meth)acrylate, pentadecyl (meth)acrylate, hexadecyl

(meth)acrylate, heptadecyl (meth)acrylate, stearyl (meth)acrylate, isostearyl (meth)acrylate, nonadecyl (meth)acrylate, and eicosyl (meth)acrylate.

[0050]

Among these, it is preferable to use at least a C₄₋₂₀ alkyl (meth)acrylate and it is more preferable to use at least a C₄₋₁₈ alkyl (meth)acrylate. Particularly preferable C₄₋₂₀ alkyl (meth)acrylates include n-butyl acrylate (BA) and 2-ethylhexyl acrylate (2EHA). Other specific examples of C₄₋₂₀ alkyl (meth)acrylates that can be preferably used include isononyl acrylate, n-butyl methacrylate (BMA), 2-ethylhexyl methacrylate (2EHMA), and isostearyl acrylate (iSTA). Among these C₄₋₂₀ alkyl (meth)acrylates, solely one species or a combination of two or more species can be used.

[0051]

The monomers preferably include, for instance, one or each of n-butyl acrylate (BA) and 2-ethylhexyl acrylate (2EHA). In some embodiments, the monomers preferably include at least BA. Here, examples of the monomers containing at least BA include monomers whose composition includes BA, but not 2EHA as well as monomers whose composition includes BA and 2EHA with the 2EHA content less than the BA content (e.g. the 2EHA content being less than 0.5 times or less than 0.3 times the BA content).

[0052]

In some embodiments, the monomers forming the acrylic polymer (A) may include 40 % (by weight) or more C₄₋₁₈ alkyl (meth)acrylate. The ratio of C₄₋₁₈ alkyl (meth)acrylate in the monomers can be, for instance, 50 % by weight or higher, 60 % by weight or higher, or even 65 % by weight or higher.

From the standpoint of enhancing the cohesion of the PSA layer to prevent cohesive failure, the ratio of C₄₋₁₈ alkyl (meth)acrylate in the monomers is suitably 99.5 % by weight or lower; it can be 95 % by weight or lower, 85 % by weight or lower, or even 75 % by weight or lower.

[0053]

In addition to the alkyl (meth)acrylate, the monomers forming the acrylic polymer (A) may include, as necessary, another monomer (copolymerizable monomer) that is able to copolymerize with the alkyl (meth)acrylate. As the copolymerizable monomer, a monomer having a polar group (such as a carboxy group, a hydroxy group and a nitrogen atom-containing ring) or a monomer having a relatively high homopolymer glass transition temperature (e.g. 10 °C or higher) may be suitably used.

The monomer having a polar group may be useful for introducing cross-linking points into the acrylic polymer (A) or increasing the PSA's cohesive strength. For the copolymerizable monomer, solely one species or a combination of two or more species can be used.

[0054]

Non-limiting specific examples of the copolymerizable monomer include those indicated below.

Carboxy group-containing monomers: for example, acrylic acid, methacrylic acid, carboxyethyl acrylate, carboxypentyl acrylate, itaconic acid, maleic acid, fumaric acid, crotonic acid and isocrotonic acid;

Acid anhydride group-containing monomers: for example, maleic anhydride and itaconic anhydride;

Hydroxy group-containing monomers: for example, hydroxyalkyl (meth)acrylates such as 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, 4-hydroxybutyl (meth)acrylate, 6-hydroxyhexyl (meth)acrylate, 8-hydroxyoctyl (meth)acrylate, 10-hydroxydecyl (meth)acrylate, 12-hydroxyauryl (meth)acrylate and (4-hydroxymethylcyclohexyl)methyl (meth)acrylate;

Monomers having a sulphonate group or a phosphate group: for example, styrene sulphonic acid, allyl sulphonic acid, sodium vinylsulphonate, 2-(meth)acrylamide-2-methylpropane sulphonic acid, (meth)acrylamide propane sulphonic acid, sulphopropyl (meth)acrylate, (meth)acryloyloxy naphthalenesulphonic acid and 2-hydroxyethylacryloyl phosphate;

Epoxy group-containing monomers: for example, epoxy group-containing acrylates such as glycidyl (meth)acrylate and (meth)acrylate-2-ethyl glycidyl ether, allyl glycidyl ether and (meth)acrylate glycidyl ether;

Cyano group-containing monomers: for example, acrylonitrile and methacrylonitrile;

Isocyanato group-containing monomers: for example, 2-isocyanatoethyl (meth)acrylate;

Amido group-containing monomers: for example, (meth)acrylamide; N,N-dialkyl (meth)acrylamides such as N,N-dimethyl(meth)acrylamide, N,N-diethyl(meth)acrylamide, N,N-dipropyl(meth)acrylamide, N,N-

diisopropyl(meth)acrylamide, N,N-di(n-butyl)(meth)acrylamide and N,N-di(t-butyl)(meth)acrylamide; N-alkyl (meth)acrylamides such as N-ethyl(meth)acrylamide, N-isopropyl(meth)acrylamide, N-butyl(meth)acrylamide and N-n-butyl(meth)acrylamide; N-vinylcarboxylic acid amides such as N-vinylacetamide; a monomer having a hydroxy group and an amide group, for example, an N-hydroxyalkyl(meth)acrylamide such as N-(2-hydroxyethyl)(meth)acrylamide, N-(2-hydroxypropyl)(meth)acrylamide, N-(1-hydroxypropyl)(meth)acrylamide, N-(3-hydroxypropyl)(meth)acrylamide, N-(2-hydroxybutyl)(meth)acrylamide, N-(3-hydroxybutyl)(meth)acrylamide, and N-(4-hydroxybutyl)(meth)acrylamide; a monomer having an alkoxy group and an amide group, for example, an N-alkoxyalkyl(meth)acrylamide such as N-methoxymethyl(meth)acrylamide, N-methoxyethyl(meth)acrylamide, and N-butoxymethyl(meth)acrylamide; and N,N-dimethylaminopropyl(meth)acrylamide, N-(meth)acryloylmorpholine, etc.

Amino group-containing monomers: for example, aminoethyl (meth)acrylate, N,N-dimethylaminoethyl (meth)acrylate and t-butylaminoethyl (meth)acrylate.

Epoxy group-containing monomers: for example, glycidyl (meth)acrylate, methylglycidyl (meth)acrylate, and allyl glycidyl ether.

Monomers having a nitrogen atom-containing ring: for example, N-vinyl-2-pyrrolidone, N-methylvinylpyrrolidone, N-vinylpyridine, N-vinylpiperidone, N-vinylpyrimidine, N-vinylpiperazine, N-vinylpyrazine, N-vinylpyrrole, N-vinylimidazole, N-vinyloxazole, N-(meth)acryloyl-2-pyrrolidone, N-(meth)acryloylpiperidine, N-(meth)acryloylpyrrolidine, N-vinylmorpholine, N-vinyl-3-morpholinone, N-vinyl-2-caprolactam, N-vinyl-1,3-oxazin-2-one, N-vinyl-3,5-morpholinedione, N-vinylpyrazole, N-vinylisoxazole, N-vinylthiazole, N-vinylisothiazole and N-vinylpyridazine (such as lactams including N-vinyl-2-caprolactam);

Monomers having a succinimide backbone: for example, N-(meth)acryloyloxy methylene succinimide, N-(meth)acryloyl-6-oxy hexamethylene succinimide and N-(meth)acryloyl-8-oxy hexamethylene succinimide;

Maleimides: for example, N-cyclohexylmaleimide, N-isopropylmaleimide, N-laurylmaleimide and N-phenylmaleimide;

Itaconimides: for example, N-methyl itaconimide, N-ethyl itaconimide, N-butyl itaconimide, N-octyl itaconimide, N-2-ethylhexyl itaconimide, N-cyclohexyl itaconimide and N-lauryl itaconimide;

Aminoalkyl (meth)acrylates: for example, aminoethyl (meth)acrylate, N,N-dimethylaminoethyl (meth)acrylate, N,N-diethylaminoethyl (meth)acrylate and t-butylaminoethyl (meth)acrylate;

Alkoxy group-containing monomers: for example, alkoxyalkyl (meth)acrylates such as 2-methoxyethyl (meth)acrylate, 3-methoxypropyl (meth)acrylate, 2-ethoxyethyl (meth)acrylate, propoxyethyl (meth)acrylate, butoxyethyl (meth)acrylate and ethoxypropyl (meth)acrylate; and alkoxy alkylene glycol (meth)acrylates such as methoxy ethylene glycol (meth)acrylate, methoxy poly(ethylene glycol) (meth)acrylate and methoxy poly(propylene glycol) (meth)acrylate;

Alkoxysilyl group-containing monomers: for example, alkoxysilyl group-containing (meth)acrylates such as (3-(meth)acryloxypropyl)trimethoxysilane, (3-(meth)acryloxypropyl)triethoxysilane, (3-(meth)acryloxypropyl)methyldimethoxysilane, (3-(meth)acryloxypropyl)methyldiethoxysilane; and alkoxysilyl group-containing vinyl compounds such as vinyltrimethoxysilane and vinyltriethoxysilane;

Vinyl esters: for example, vinyl acetate and vinyl propionate;

Vinyl ethers: for example, vinyl alkyl ethers such as methyl vinyl ether and ethyl vinyl ether;

Aromatic vinyl compounds: for example, styrene, α -methylstyrene and vinyl toluene;

Olefins: for example, ethylene, butadiene, isoprene and isobutylene;

(Meth)acrylic esters having alicyclic hydrocarbon groups: for example, alicyclic hydrocarbon group-containing (meth)acrylates such as cyclopentyl (meth)acrylate, cyclohexyl (meth)acrylate, isobornyl (meth)acrylate, dicyclopentanyl (meth)acrylate, and adamantyl (meth)acrylate;

(Meth)acrylic esters having aromatic hydrocarbon groups: for example, aromatic hydrocarbon group-containing (meth)acrylates such as phenyl (meth)acrylate, phenoxyethyl (meth)acrylate and benzyl (meth)acrylate;

Heterocyclic ring-containing (meth)acrylates such as tetrahydrofurfuryl (meth)acrylate, halogen atom-containing (meth)acrylates such as vinyl chloride and fluorine atom-containing (meth)acrylates, silicon atom-containing (meth)acrylates such as silicone (meth)acrylate, (meth)acrylic esters obtained from terpene compound derivative alcohols and the like.

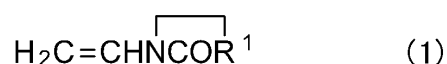
[0055]

When using such a copolymerizable monomer, its amount used is not particularly limited, but it is suitably at least 0.01 % by weight of the entire monomers. From the standpoint of obtaining greater effect of the use of the copolymerizable monomer, the amount of copolymerizable monomer used can be 0.1 % by weight or more of the entire monomers, or even 0.5 % by weight or more. For easy balancing of adhesive properties, the amount of copolymerizable monomer used is suitably 50 % by weight or less of the entire monomers, or preferably 40 % by weight or less.

[0056]

In some embodiments, the monomers forming the acrylic polymer (A) may include a monomer having a nitrogen atom (N). The use of the N-containing monomer may help increase the PSA's cohesive strength and preferably increase the peel strength after photo-cured. A favorable example of the N-containing monomer is a monomer having a N-containing ring (N-containing cyclic monomer). As the N-containing cyclic monomer, those exemplified above and the like can be used. For instance, it is possible to use a cyclic N-vinyl amide represented by general formula (1):

[Chem 1]



Here, in general formula (1), R¹ is a divalent organic group, in particular, -(CH₂)_n-; and n is an integer between 2 to 7 (preferably 2, 3 or 4). In particular, N-vinyl-2-pyrrolidone can be preferably used. Other favorable examples of the N-containing monomer include (meth)acrylamide.

[0057]

The amount of the N-containing monomer (preferably a N-containing cyclic monomer) used is not particularly limited. For instance, it can be 1 % by weight or more, 3 % by weight or more, even 5 % by weight or more, or 7 % by weight or more of the entire monomers. In some embodiments, the amount of the N-containing monomer used can be 10 % by weight or more, 15 % by weight or more, or even 20 % by weight or more of the entire monomers. The amount of the N-containing monomer used is suitably, for instance, 40 % by weight or less of the entire monomer, possibly 35 % by weight or less, 30 % by weight or less, or even 25 % by weight or less. In other embodiments, the amount of the N-containing monomer used can be, for instance, 20 % by weight or less, or 15 % by weight or less of the entire monomers.

[0058]

In some embodiments, the monomers forming the acrylic polymer (A) may include a hydroxy group-containing monomer. With the use of hydroxy group-containing monomer, the PSA's cohesive strength and degree of crosslinking (e.g. crosslinking by an isocyanate crosslinking agent) can be favorably adjusted. When using a hydroxy group-containing monomer, its amount used can be, for instance, 0.01 % by weight or more, 0.1 % by weight or more, 0.5 % by weight or more, 1 % by weight or more, 5 % by weight or more, or even 10 % by weight or more of the entire monomers. From the standpoint of inhibiting the PSA layer's water absorption, in some embodiments, the amount of hydroxy group-containing monomer used is, for instance, suitably 40 % by weight or less of the entire monomers; it can be 30 % by weight or less, 25 % by weight or less, or even 20 % by weight or less. In some other embodiments, the hydroxy group-containing monomer can be used in an amount of, for instance, 15 % by weight or less, 10 % by weight or less, or even 5 % by weight or less of the entire monomers.

[0059]

In some embodiments, the carboxy group-containing monomer content in the monomers of acrylic polymer (A) can be, for instance, 2 % by weight or less, 1 % by weight or less, or even 0.5 % by weight or less (e.g. below 0.1 % by weight). A carboxy group-containing monomer may not be essentially used as the monomers of acrylic polymer (A). Here, that a carboxy group-containing monomer is not essentially used means no carboxy group-containing monomer is used at least intentionally. As described above, from the standpoint of preventing metal corrosion, the PSA layer preferably comprises an acrylic polymer (A) in which the carboxy group-containing monomer is used in a limited amount. For instance, such a PSA layer can be preferably used even in an embodiment where it is in contact with an adherend having a metal material.

[0060]

In some embodiments, the monomers forming the acrylic polymer (A) may include an alicyclic hydrocarbon group-containing (meth)acrylate. This can increase the PSA's cohesive strength as well as its peel strength after photocured. As the alicyclic hydrocarbon group-containing (meth)acrylate, the examples given earlier and the like can be used. For instance, cyclohexyl acrylate and isobornyl acrylate can be preferably used. When using an alicyclic hydrocarbon group-containing (meth)acrylate, its amount used is not particularly limited. For instance, it can be 1 % by weight or more, 3 % by weight or

more, or 5 % by weight or more of the entire monomers. In some embodiments, the amount of alicyclic hydrocarbon group-containing (meth)acrylate used can be 10 % by weight or more, or even 15 % by weight or more of the entire monomers. The maximum amount of alicyclic hydrocarbon group-containing (meth)acrylate used is suitably about 40 % by weight or less, for instance, possibly 30 % by weight or less, or even 25 % by weight or less (e.g. 15 % by weight or less, or even 10 % by weight or less).

[0061]

The polymerization method for forming (synthesizing) the polymer (A) from monomers is not particularly limited. Various conventionally known polymerization methods can be suitably employed. Examples of the polymerization method that can be suitably employed include thermal polymerization (typically carried out in the presence of a thermal polymerization initiator) such as solution polymerization, emulsion polymerization and bulk polymerization; photopolymerization (typically carried out in the presence of a photopolymerization initiator) involving irradiation of light such as UV rays; and radiation polymerization involving irradiation of radioactive rays such as β rays and γ rays. Two or more polymerization methods can be carried out in combination (e.g. stepwise).

[0062]

As the solvent (polymerization solvent) for solution polymerization, one kind of solvent or a solvent mixture of two or more kinds can be used, selected among, for instance, aromatic compounds (typically aromatic hydrocarbons) such as toluene; esters such as ethyl acetate and butyl acetate; aliphatic or alicyclic hydrocarbons such as hexane and cyclohexane; halogenated alkanes such as 1,2-dichloroethane; lower alcohols (e.g. monohydric alcohols with 1 to 4 carbon atoms) such as isopropanol; ethers such as tert-butyl methyl ether; and ketones such as methyl ethyl ketone.

[0063]

In the polymerization, a known or commonly used thermal polymerization initiator or photopolymerization initiator can be used in accordance with the polymerization method and polymerization conditions. These polymerization initiators can be used solely as one species or in a combination of two or more species.

[0064]

The thermal polymerization initiator is not particularly limited. For example, azo-based polymerization initiator, peroxide-based polymerization initiator, a redox-based

polymerization initiator by combination of a peroxide and a reducing agent, substituted ethane-based polymerization initiator and the like can be used. More specific examples include, but not limited to, azo-based initiators such as 2,2'-azobisisobutyronitrile (AIBN), 2,2'-azobis(2-methylpropionamidine) disulfate, 2,2'-azobis(2-amidinopropane) dihydrochloride, 2,2'-azobis[2-(5-methyl-2-imidazolin-2-yl)propane] dihydrochloride, 2,2'-azobis(N,N'-dimethyleneisobutylamidine), and 2,2'-azobis[N-(2-carboxyethyl)-2-methylpropionamidine] hydrate; persulfates such as potassium persulfate and ammonium persulfate; peroxide-based initiators such as benzoyl peroxide, t-butyl hydroperoxide, and hydrogen peroxide; substituted ethane-based initiators such as phenyl-substituted ethane; redox-based initiators such as combination of a persulfate salt and sodium hydrogen sulfite, and combination of a peroxide and sodium ascorbate. Thermal polymerization can be preferably carried out at a temperature of, for instance, about 20 °C to 100 °C (typically 40 °C to 80 °C) while not limited to these ranges.

[0065]

The photopolymerization initiator is not particularly limited. It is possible to use, for instance, ketal-based photopolymerization initiators, acetophenone-based photopolymerization initiators, benzoin ether-based photopolymerization initiators, acylphosphine oxide-based photopolymerization initiators, α -ketol photopolymerization initiators, aromatic sulphonyl chloride-based photopolymerization initiators, photoactive oxime-based photopolymerization initiators, benzoin-based photopolymerization initiators, benzylic photopolymerization initiators, benzophenone-based photopolymerization initiators, and thioxanthone-based photopolymerization initiators.

[0066]

Such photopolymerization initiator can be used in a usual amount in accordance with the polymerization method, embodiment of polymerization, etc., and there are no particular limitations to the amount. For instance, relative to 100 parts by weight of monomers to be polymerized, about 0.001 part to 5 parts by weight (typically about 0.01 part to 2 parts by weight, e.g. about 0.01 part to 1 part by weight) of polymerization initiator can be used.

[0067]

In the polymerization, various kinds of heretofore known chain transfer agent (which may also be thought as molecular weight-adjusting agent or polymerization degree-adjusting agent) can be used as necessary. As the chain transfer agent,

mercaptans can be preferably used, such as n-dodecyl mercaptan, t-dodecyl mercaptan, thioglycolic acid and α -thioglycerol. Alternatively, a chain transfer agent free of sulfur atoms (a sulfur-free chain transfer agent) can be used as well. Specific examples of the sulfur-free chain transfer agent include anilines such as N,N-dimethylaniline and N,N-diethylaniline; terpenoids such as α -pinene and terpinolene; styrenes such as α -methylstyrene and α -methylstyrene dimer; compounds having benzylidenyl groups such as dibenzylidene acetone, cinnamyl alcohol and cinnamyl aldehyde; hydroquinones such as hydroquinone and naphthohydroquinone; quinones such as benzoquinone and naphthoquinone; olefins such as 2,3-dimethyl-2-butene and 1,5-cyclooctadiene; alcohols such as phenol, benzyl alcohol and allyl alcohol; and benzyl hydrogens such as diphenylbenzene and triphenylbenzene. For the chain transfer agent, solely one species or a combination of two or more species can be used. The art disclosed herein can also be preferably implemented in an embodiment that uses no chain transfer agent.

[0068]

When using a chain transfer agent, it can be used in an amount of, for instance, about 0.005 part to 1 part by weight to 100 parts by weight of the monomers. In some embodiments, from the standpoint of the impact strength, the amount of chain transfer agent used to 100 parts by weight of monomers can be, for instance, 0.01 part by weight or greater, 0.03 part by weight or greater, 0.05 part by weight or greater, or even 0.07 part by weight or greater. In some embodiments, from the standpoint of the deformation resistance, the amount of chain transfer agent used to 100 parts by weight of monomers can be, for instance, 0.5 part by weight or less, 0.2 part by weight or less, 0.1 part by weight or less, or even less than 0.1 part by weight (e.g. 0.09 part by weight or less).

[0069]

In the art disclosed herein, the glass transition temperature (T_g) of polymer (A) is not particularly limited. It is suitably below 0 °C, preferably below -10 °C, or more preferably below -20 °C. With decreasing T_g of polymer (A), the impact strength tends to increase. In some embodiments, the polymer (A)'s T_g can be below -25 °C, or below -30 °C. The polymer (A)'s T_g is typically -80 °C or higher, for instance, possibly -70 °C or higher, -60 °C or higher, or even -55 °C or higher. From the standpoint of increasing the elastic modulus, in some embodiments, the polymer (A)'s T_g is preferably -50 °C or higher, more preferably -45 °C or higher, possibly -40 °C or higher, -38 °C or higher, or even -35 °C or higher.

[0070]

As used herein, the polymer's Tg refers to the Tg value determined by the Fox equation based on the composition of the monomers used to prepare the polymer. As shown below, the Fox equation is a relational expression between the Tg of a copolymer and glass transition temperatures Tgi of homopolymers of the respective monomers constituting the copolymer.

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

[0071]

In the Fox equation above, Tg represents the glass transition temperature (unit: K) of the copolymer, Wi the weight fraction (copolymerization ratio by weight) of a monomer i in the copolymer, and Tgi the glass transition temperature (unit: K) of homopolymer of the monomer i. When the polymer subject to Tg determination is a homopolymer, the Tg values of the homopolymer and the subject polymer are the same.

[0072]

As the glass transition temperatures of homopolymers used for determining the Tg value, values found in publicly known documents are used. For example, with respect to the monomers listed below, as the glass transition temperatures of homopolymers of the monomers, the following values are used:

n-Butyl acrylate	-55 °C
2-Ethylhexyl acrylate	-70 °C
isostearyl acrylate	-18 °C
Cyclohexyl acrylate	15 °C
N-vinyl-2-pyrrolidone	54 °C
2-Hydroxyethyl acrylate	-15 °C
4-Hydroxybutyl acrylate	-40 °C

[0073]

With respect to the glass transition temperatures of homopolymers of monomers other than those listed above, values given in "Polymer Handbook" (3rd edition, John Wiley & Sons, Inc., Year 1989) are used. When the literature provides two or more values, the highest value is used.

[0074]

The weight average molecular weight (Mw) of the polymer (A) is not particularly limited. From the standpoint of combining well-balanced deformation resistance and

impact strength, in some embodiments, the polymer (A)'s Mw is suitably, for instance, about 10×10^4 or higher, preferably above 20×10^4 , possibly above 30×10^4 , above 40×10^4 , or even above 50×10^4 . The maximum Mw of the polymer (A) can be about 500×10^4 or below. From the standpoint of the tightness of adhesion to adherends and the peel strength, in some embodiments, the polymer (A)'s Mw can be, for instance, 300×10^4 or lower, possibly 150×10^4 or lower, 100×10^4 or lower, 90×10^4 or lower, or even 75×10^4 or lower.

The exemplified Mw ranges can be applied to the polymer (A)'s Mw in the PSA layer disclosed herein or to the polymer (A)'s Mw in the PSA composition used for forming the PSA layer.

[0075]

The Mw refers to the value based on polystyrene standards determined by gel permeation chromatography (GPC). As the GPC analyzer, it is possible to use model name HLC-8220GPC (Tosoh Corporation) or a comparable product. As for the conditions of GPC analysis, for instance, the method described below is employed. The Mw values in the working examples described later are determined by the following method:

(Conditions of GPC analysis)

System: HLC-8220GPC available from Tosoh Corporation

Columns:

Sample columns: TSKguard column Super HZ-H ($\times 1$) + TSKgel Super HZM-H ($\times 2$) available from Tosoh Corporation

Reference column: TSKgel Super H-RC ($\times 1$) available from Tosoh Corporation

Flow rate: 0.6 mL/min

Injection volume: 10 μ L

Column temperature: 40 °C

Eluent: THF

Sample concentration: 0.2 % by weight

Detector: differential refractometer

Weight average molecular weights are determined based on polystyrene standards.

[0076]

(Photoreactive monomer (B))

In some embodiments, the PSA layer may comprise a photoreactive monomer (B)

in addition to an aforementioned polymer (A) (e.g. acrylic polymer (A)). As the photoreactive monomer (B), it is possible to use a compound having two or more ethylenically unsaturated groups (or “functional groups” hereinafter) per molecule. The maximum number of functional groups in the compound used as the photoreactive monomer (B) is not particularly limited. The number of functional groups can be, for instance, 50 or lower, 40 or lower, 30 or lower, 20 or lower, or even 15 or lower. In some embodiments, a compound having, for instance, 2 to 10 functional groups (ethylenically unsaturated groups) can be used. A preferable compound has 2 to 8 functional groups and a more preferable compound has 2 to 6 functional groups. For the photoreactive monomer (B), solely one species or a combination of two or more species can be used.

[0077]

The photoreactive monomer (B) in the PSA layer can form a crosslinked structure when the ethylenically unsaturated group reacts upon irradiation of light (e.g. UV), etc., after applied to an adherend. In the PSA layer comprising a photoreactive monomer (B), the PSA layer's deformation resistance can be enhanced by allowing the PSA layer to cure by UV irradiation following its application to an adherend, etc. This can favorably combine good conformity to surface contours of adherends when applied to adherends and high deformation resistance after applied.

[0078]

Examples of the ethylenically unsaturated group include, but are not limited to acryloyl group, methacryloyl group, vinyl group and allyl group. The two or more ethylenically unsaturated group in the molecule of photoreactive monomer (B) can be the same group or can be two or more different groups. Examples of ethylenically unsaturated groups preferable from the standpoint of the photoreactivity include acryloyl group and methacryloyl group. In particular, acryloyl group is preferable.

[0079]

The functional group equivalent weight of the compound used as the photoreactive monomer (B) is not particularly limited. The functional group equivalent weight can be, for instance, about 50 g/mol to 10000 g/mol, about 50 g/mol to 8000 g/mol, about 50 g/mol to 5000 g/mol, about 50 g/mol to 3000 g/mol, or even about 50 g/mol to 2000 g/mol. In some embodiments, from the standpoint of the photocuring properties, a compound having a functional group equivalent weight of about 60 g/mol to 800 g/mol (more preferably about 80 g/mol to 600 g/mol) can be preferably used as the photoreactive

monomer (B).

[0080]

The photoreactive monomer (B)'s functional group equivalent weight is determined by dividing the photoreactive monomer (B)'s molecular weight (g/mol) by the number of ethylenically unsaturated functional groups in the photoreactive monomer (B). The photoreactive monomer (B)'s molecular weight can be obtained, for instance, by GPC, as a weight average molecular weight based on standard polystyrenes. As the photoreactive monomer (B)'s molecular weight (g/mol), the manufacturer's nominal value or molecular weight calculated from the molecular structure can be used as well.

[0081]

The photoreactive monomer (B)'s molecular weight is not particularly limited and can be selected to favorably bring about the desired effect. For instance, a photoreactive monomer (B) having a molecular weight of about 20000 or lower can be used. From the standpoint of the ease of preparing and applying the PSA composition, etc., in some embodiments, the photoreactive monomer (B) has a molecular weight of, for instance, 16000 or lower, 10000 or lower, 4000 or lower, 1500 or lower, or even 1000 or lower. The photoreactive monomer (B) has a molecular weight of, for instance, 100 or higher, typically 120 or higher. From the standpoint of the ease of processing and handling, etc., in some embodiments, the photoreactive monomer (B) has a molecular weight of, for instance, 150 or higher, 200 or higher, 280 or higher, 350 or higher, 420 or higher, 480 or higher, or even 550 or higher.

[0082]

In the laminate disclosed herein, the amount of photoreactive monomer (B) in the PSA layer is not particularly limited and can be suitably selected in accordance with the projected properties (e.g. elastic modulus of the photocured PSA layer). In some embodiments where the PSA layer comprises a polymer (A) and a photoreactive monomer (B), the amount of photoreactive monomer (B) relative to 100 parts by weight of polymer (A) in the PSA layer can be, for instance, 1 part by weight or greater, or suitably 3 parts by weight or greater. From the standpoint of the ease of increasing the elastic modulus of the photocured PSA layer, the amount of photoreactive monomer (B) relative to 100 parts by weight of polymer (A) can be 5 parts by weight or greater, 10 parts by weight or greater, 15 parts by weight or greater, or even 20 parts by weight or greater. From the standpoint of the PSA layer's cohesion and handling properties (e.g. ease of processing)

prior to photocuring, the amount of photoreactive monomer (B) relative to 100 parts by weight of polymer (A) is suitably 80 parts by weight or less, preferably 60 parts by weight or less, 50 parts by weight or less, 40 parts by weight or less, or even 35 parts by weight or less.

[0083]

In some embodiments, the PSA layer preferably comprises, as the photoreactive monomer (B), a compound B1 having a ring structure and two or more ethylenically unsaturated groups per molecule. With the PSA layer comprising a compound B1 having such a structure, photoirradiation can effectively increase the deformation resistance of the PSA layer. The ring structure can be an aliphatic or aromatic ring. The ring can be a carbocycle or heterocycle. One molecule of compound B1 may include one, two or more rings. The maximum number of rings in the compound B1 is not particularly limited. For instance, it can be 100 or lower, 70 or lower, 50 or lower, 30 or lower, 15 or lower, 8 or lower, 6 or lower, 5 or lower, or even 4 or lower. When the compound B1 includes two or more rings, these rings may or may not form a condensed (fused) ring (typically, a bicyclic or tricyclic condensed ring). The ring is preferably in the main chain of compound B1. In other words, at least two ethylenically unsaturated groups in the compound B1 are preferably connected through the ring structure. For the compound B1, solely one species or a combination of two or more species can be used.

[0084]

As the compound B1, it is preferable to use a compound that has a ring structure and at least two ethylenically unsaturated groups per molecule and has a functional group equivalent weight of 100 g/mol or higher. With the PSA layer comprising a compound B1 that satisfies the functional group equivalent weight, a highly deformation-resistant and highly impact-resistant bonding can be favorably formed. Reasons attributed to such effect should not be interpreted in a particularly limited way, but the following can be presumed: With the compound B1, the rigidity of the ring structure can effectively increase the elastic modulus of the PSA layer after photoirradiation to provide deformation resistance; on the other hand, with the compound B1 having at least the prescribed functional group equivalent weight, crosslinking points can be kept apart to form a highly impact-resistant crosslinked structure. In some embodiments, the compound B1's functional group equivalent weight can be, for instance, 120 g/mol or higher, 150 g/mol or higher, 180 g/mol or higher, 230 g/mol or higher, 280 g/mol or higher,

320 g/mol or higher, or even 350 g/mol or higher. With increasing functional group equivalent weight of the compound B1, the impact strength tends to increase. The compound B1's functional group equivalent weight can be, for instance, 10000 g/mol or lower, 8000 g/mol or lower, 5000 g/mol or lower, 3000 g/mol or lower, or even 2000 g/mol or lower. In some embodiments, from the standpoint of the photocuring properties, etc., the compound B1's functional group equivalent weight is preferably 800 g/mol or lower, or more preferably 600 g/mol or lower. In some embodiments, the compound B1's functional group equivalent weight can be 500 g/mol or lower, 400 g/mol or lower, or even 300 g/mol or lower.

[0085]

In some embodiments, the number of functional groups in the compound B1 can be, for instance, 2 to 50, 2 to 40, 2 to 30, 2 to 10, for instance, preferably 2 to 6, possibly 2 to 4, or even 2 to 3. In some embodiments, a compound B1 having two or more functional groups can be preferably used.

[0086]

The compound B1 may have other functional groups besides the ethylenically unsaturated group. Examples of the non-ethylenically-unsaturated groups include hydroxy group, carboxy group and amino groups. Favorable examples of the non-ethylenically-unsaturated groups include hydroxy group and amino groups.

[0087]

Examples of the compound B1 include, but are not limited to, bisphenol A-based epoxy (meth)acrylates such as bisphenol A glycidyl ether (meth)acrylic acid adduct, bisphenol A glycidyl amine (meth)acrylic acid adduct, and bisphenol A glycidyl ester (meth)acrylic acid adduct; alkylene oxide-modified bisphenol A (meth)acrylates such as ethylene oxide (EO)-modified bisphenol A di(meth)acrylate and propylene oxide (PO)-modified bisphenol A di(meth)acrylate; bisphenol F-based epoxy (meth)acrylates such as bisphenol F glycidyl ether (meth)acrylic acid adduct, bisphenol F glycidyl amine (meth)acrylic acid adduct, and bisphenol F glycidyl ester (meth)acrylic acid adduct; alkylene oxide-modified bisphenol F (meth)acrylates such as EO-modified bisphenol F di(meth)acrylate and PO-modified bisphenol F di(meth)acrylate; bisphenol E-based (meth)acrylates such as bisphenol E glycidyl ether (meth)acrylic acid adduct, bisphenol E glycidyl amine (meth)acrylic acid adduct, and bisphenol E glycidyl ester (meth)acrylic acid adduct; alkylene oxide-modified bisphenol E (meth)acrylates such as EO-modified

bisphenol E di(meth)acrylate and PO-modified bisphenol E di(meth)acrylate; fluorene structure-containing (meth)acrylates such as 9,9-bis(4-hydroxyphenyl)fluorene di(meth)acrylate and 9,9-bis[4-(2-hydroxyethoxy)phenyl]fluorene di(meth)acrylate; (meth)acrylates having aliphatic rings (possibly aliphatic condensed rings), such as tricyclodecane dimethanol di(meth)acrylate, hydrogenated bisphenol A-based epoxy (meth)acrylates, hydrogenated bisphenol F-based epoxy (meth)acrylates, bisphenol E-based epoxy (meth)acrylates, hydrogenated phthalic acid-based epoxy (meth)acrylates, hydrogenated terpene phenol (meth)acrylates, and 1,4-cyclohexane dimethanol diglycidyl ether (meth)acrylate; novolac-based epoxy resin and (meth)acrylic acid adducts; thioether-based resin and (meth)acrylic acid adducts; naphthalene-based epoxy resin and (meth)acrylic acid adducts; dicyclopentadiene-based epoxy resin and (meth)acrylic acid adducts; alkyl diphenol-based epoxy resin and (meth)acrylic acid adducts; biphenyl-based epoxy resin and (meth)acrylic acid adducts; terpene phenol resin and (meth)acrylic acid adducts; isocyanurate-based (meth)acrylates such as tris(2-hydroxyethyl)isocyanurate di(meth)acrylate and tris(2-hydroxyethyl)isocyanurate tri(meth)acrylate; divinyl benzene; hydroxyquinone di(meth)acrylate; resorcin (meth)acrylate; and a product of modification (e.g. amine modification, acid modification, halogen modification) of any material described above. In some embodiment, a compound B1 having an aromatic carbon ring can be preferably used. Favorable examples of the compound B1 include bisphenol A structure-containing compounds such as bisphenol A-based epoxy (meth)acrylates, alkylene oxide-modified bisphenol A (meth)acrylates, and modification (e.g. amine modification) products of these.

[0088]

Commercial products that can be used as the compound B1 include, but are not limited to, product names A-DCP and A-BPE-4 available from Shin-Nakamura Chemical Co., Ltd.; product names BISCOAT #540 and BISCOAT #700HV available from Osaka Organic Chemical Ind., Ltd.; product name R-114F available from Nippon Kayaku Co., Ltd.; product names EPOXY ESTER 3000A and EPOXY ESTER 80MFA available from Kyoisha Chemical Co., Ltd.; product names EBECRYL 3700, EBECRYL 3703 and EBECRYL 3603 available from Daicel Allnex, Ltd.

[0089]

The amount of compound B1 per 100 parts by weight of polymer (A) in the PSA layer is not particularly limited. For instance, it can be 0.5 part by weight or greater.

From the standpoint of the ease of obtaining a PSA layer that combines well-balanced deformation resistance and impact strength, in some embodiments, the amount of compound B1 per 100 parts by weight of polymer (A) can be, for instance, 1 part by weight or greater, 3 parts by weight or greater, 5 parts by weight or greater, 7 parts by weight or greater, 10 parts by weight or greater, or even 15 parts by weight or greater. From the standpoint of the cohesion of the pre-photocured PSA layer and the handling properties, the amount of compound B1 per 100 parts by weight of polymer (A) is suitably 80 parts by weight or less, preferably 60 parts by weight or less, possibly 50 parts by weight or less, 40 parts by weight or less, 35 parts by weight or less, 25 parts by weight or less, or even 15 parts by weight or less.

[0090]

In some embodiments, the PSA layer may comprise, as the photoreactive monomer (B), a compound B2 having two or more functional groups and being free of a ring structure per molecule. The compound B2 is preferably used in combination with a compound B1. This may allow adjustment of the PSA layer's crosslinking structure and formation of bonding that more favorably combines deformation resistance and impact resistance. For the compound B2, solely one species or a combination of two or more species can be used.

[0091]

The number of functional groups in the compound B2 can be, for instance, 50 or lower, 40 or lower, 30 or lower, 20 or lower, or even 15 or lower. The number of functional groups in the compound B2 used in some embodiments is, for instance, possibly 2 to 10, preferably 3 to 10, also possibly 3 to 8, or even 4 to 6. For instance, in an embodiment using a compound having two functional groups as the compound B1, it may be advantageous to use a compound B2 having 3 or more (preferably 4 or more, more preferably 5 or more, yet more preferably 6 or more) functional groups.

[0092]

The functional group equivalent weight of compound B2 is not particularly limited. For instance, it can be 5000 g/mol or less, 2000 g/mol or less, or even 1000 g/mol or less. In some embodiments, the compound B2's functional group equivalent weight can be, for instance, 600 g/mol or less. From the standpoint of photocuring, increasing the hardness of the cured material, etc., it can be 400 g/mol or less, 300 g/mol or less, 200 g/mol or less, 150 g/mol or less, or even 100 g/mol or less. The compound B2's functional

group equivalent weight is typically 50 g/mol or greater, preferably 60 g/mol or greater, possibly 70 g/mol or greater, 80 g/mol or greater, or even 90 g/mol or greater.

[0093]

Examples of the compound that can be used as the compound B2 include, but are not limited to, pentaerythritol tri(meth)acrylate, pentaerythritol tetra(meth)acrylate, dipentaerythritol tetra(meth)acrylate, dipentaerythritol penta(meth)acrylate, dipentaerythritol hexa(meth)acrylate, trimethylol propane tri(meth)acrylate, di(trimethylol propane) tetra(meth)acrylate, trimethylol ethane tri(meth)acrylate, tetramethylol methane tri(meth)acrylate, neopentyl glycol di(meth)acrylate, neopentyl glycol hydroxypivalate ester di(meth)acrylate, pentaerythritoldi(meth)acrylate, allyl (meth)acrylate, and vinyl (meth)acrylate; as well as EO-modification and PO-modification products of any of these materials.

[0094]

In an embodiment using a compound B2, the amount of compound B2 per 100 parts by weight of polymer (A) in the PSA layer is not particularly limited. For instance, it can be 0.1 part by weight or greater. From the standpoint of the ease of obtaining a PSA layer that combines well-balanced deformation resistance and impact strength, in some embodiments, the amount of compound B2 per 100 parts by weight of polymer (A) can be, for instance, 1 part by weight or greater, 2 parts by weight or greater, 4 parts by weight or greater, 6 parts by weight or greater, 10 parts by weight or greater, or even 12 parts by weight or greater. From the standpoint of minimizing the decrease in tightness of adhesion with adherends caused by excessive crosslinking, in some embodiments, the amount of compound B2 per 100 parts by weight of polymer (A) is, for instance, suitably 25 parts by weight or less, preferably 17 parts by weight or less, possibly 15 parts by weight or less, 13 parts by weight or less, or even 9 parts by weight or less.

[0095]

In an embodiment using a compound B1 and compound B2 in combination, as the compound B2, it is preferable to use a compound that has at least three functional groups and has a lower functional group equivalent weight than that of the compound B1 used in combination. In some embodiments, the ratio (FE_2/FE_1) of the compound B2's functional group equivalent weight FE_2 to the compound B1's functional group equivalent weight FE_1 can be, for instance, 0.9 or lower, 0.7 or lower, 0.5 or lower, or even 0.4 or lower. According to such an embodiment, the photoreactive monomer (B) can efficiently

produce the elastic modulus-increasing effect. The minimum FE_2/FE_1 ratio value is not particularly limited and can be, for instance, 0.01 or higher, 0.1 or higher, or even 0.2 or higher.

[0096]

In an embodiment using a compound B1 and compound B2 in combination, the weight ratio (W_2/W_1) of the amount W_2 of compound B2 used to the amount W_1 of compound B1 used is not particularly limited. In some embodiments, the W_2/W_1 weight ratio value can be, for instance, 0.05 to 10, 0.1 to 5, 0.2 to 3, or even 0.3 to 2. With the W_2/W_1 weight ratio in any of the ranges above, the effect of the combined use of compound B1 and compound B2 tends to be favorably obtained.

[0097]

In other embodiments using a photoreactive monomer (B) (typically a compound B2), the amount of photoreactive monomer (B) (typically a compound B2) used is possibly about 3 % by weight or less, preferably about 2 % by weight or less, or more preferably about 1 % by weight or less (e.g. about 0.5 % by weight or less) of the monomers of the polymer (A). When using a photoreactive monomer (B) (typically a compound B2), the minimum amount used is not particularly limited as long as it is above 0 % by weight. The amount of photoreactive monomer (B) (typically a compound B2) used is suitably about 0.001 % by weight or more (e.g. about 0.01 % by weight or more) of the monomers.

[0098]

In some embodiments, the photoreactive monomer (B) can be included in the free form (as a free monomer) in the PSA layer. Such a PSA layer can be formed using a PSA composition comprising the photoreactive monomer (B) in the free form. The “free form” here means that the photoreactive monomer (B) is not chemically bonded to other component(s) (e.g. polymer (A)) in the PSA layer or PSA composition. The PSA composition comprising the photoreactive monomer (B) in the free form can be advantageous from the standpoint of facil preparation and reduction of gelation.

[0099]

In other embodiments, from the standpoint of easier processing, etc., the PSA layer may include at least some of the photoreactive monomer (B) in a form chemically bonded to another component (e.g. polymer (A)) of the PSA layer or PSA composition. The chemical bond can be formed by reaction between a non-ethylenically-unsaturated group F1 in the molecule of photoreactive monomer (B) and a functional group F2 in the

molecule of the other component reactive with the functional group F1. The other component can be a crosslinking agent via which the photoreactive monomer (B) is bonded to the polymer (A).

[0100]

(Acrylic oligomer)

The PSA layer disclosed herein can include an acrylic oligomer from the standpoint of enhancing the adhesion to its adjacent face (e.g. a transparent member or decorative film). The PSA layer comprising an acrylic oligomer can be preferably formed using a PSA composition comprising the acrylic oligomer. A preferable acrylic oligomer has a higher Tg than the polymer (A)'s Tg described earlier.

[0101]

The acrylic oligomer's Tg is not particularly limited. It can be, for instance, about 20 °C or higher and 300 °C or lower. The Tg can also be, for instance, about 30 °C or higher, about 40 °C or higher, about 60 °C or higher, about 80 °C or higher, or even about 100 °C or higher. With increasing acrylic oligomer's Tg, the effect to increase the cohesive strength generally tends to improve. From the standpoint of the adhesion to adherends, impact absorption, etc., the acrylic oligomer's Tg can be, for instance, about 250 °C or lower, about 200 °C or lower, about 180 °C or lower, or even about 150 °C or lower. Just as the Tg of the polymer (A), the acrylic oligomer's Tg value is determined by the Fox equation.

[0102]

The acrylic oligomer's Mw is not particularly limited. For instance, it is possibly about 1000 or higher, suitably about 1500 or higher, also possibly about 2000 or higher, or even about 3000 or higher. The acrylic oligomer's Mw is, for instance, possibly below about 30000, suitably below about 10000, also possibly below about 7000, or even below about 5000. When the Mw is in these ranges, it is likely to favorably enhance the PSA layer's cohesion and adhesion to its adjacent face. The acrylic oligomer's Mw can be measured by GPC and determined based on polystyrene standards. Specifically, it is measured, for instance, at a flow rate of about 0.5 mL/min with tetrahydrofuran solvent, using two TSKgel GMH-H (20) as columns on HPLC 8020 available from Tosoh Corporation.

[0103]

Examples of the monomers forming the acrylic oligomer include (meth)acrylate

monomers such as the aforementioned various C₁₋₂₀ alkyl (meth)acrylates; the aforementioned various alicyclic hydrocarbon group-containing (meth)acrylates; the aforementioned various aromatic hydrocarbon group-containing (meth)acrylates; and (meth)acrylates obtained from terpene-derived alcohols. These can be used solely as one species or in a combination of two or more species.

[0104]

From the standpoint of enhancing the adhesion, the acrylic oligomer preferably includes, as a monomeric unit, an acrylic monomer having a relatively bulky structure, typified by an alkyl (meth)acrylate whose alkyl group has a branched structure such as isobutyl (meth)acrylate and t-butyl (meth)acrylate; an alicyclic hydrocarbon group-containing (meth)acrylate; and an aromatic hydrocarbon group-containing (meth)acrylate. When UV rays are used for the synthesis of the acrylic oligomer or for the preparation of the PSA layer, for being less likely to inhibit the polymerization, a monomer having a saturated hydrocarbon group at the ester terminus is preferable. For instance, an alkyl (meth)acrylate whose alkyl group has a branched structure and a saturated alicyclic hydrocarbon group-containing (meth)acrylate can be favorably used.

[0105]

The ratio of (meth)acrylate monomer in the entire monomers forming the acrylic oligomer is typically above 50 % by weight, preferably 60 % by weight or higher, or more preferably 70 % by weight or higher (e.g. 80 % by weight or higher, or even 90 % by weight or higher). In some preferable embodiments, the acrylic oligomer has a monomer composition essentially consisting of one, two or more species of (meth)acrylate monomer. When the monomers include an alicyclic hydrocarbon group-containing (meth)acrylate and a C₁₋₂₀ alkyl (meth)acrylate, their weight ratio is not particularly limited. In some embodiments, the alicyclic hydrocarbon group-containing (meth)acrylate/C₁₋₂₀ alkyl (meth)acrylate weight ratio can be, for instance, 10/90 or higher, 20/80 or higher, or 30/70 or higher; and it can be 90/10 or lower, 80/20 or lower, or 70/30 or lower.

[0106]

As the acrylic oligomer-forming monomers, in addition to the (meth)acrylate monomer described above, a functional group-containing monomer can be used as necessary. Examples of the functional group-containing monomer include monomers having nitrogen atom-containing heterocyclic rings such as N-vinyl-2-pyrrolidone and N-acryloylmorpholine; amino group-containing monomers such as N,N-dimethylaminoethyl

(meth)acrylate; amide group-containing monomers such as N,N-diethyl (meth)acrylamide; carboxy group-containing monomers such as AA and MAA; and hydroxy group-containing monomers such as 2-hydroxyethyl (meth)acrylate. These functional group-containing monomers can be used solely as one species or in a combination of two or more species. When a functional group-containing monomer is used, the ratio of the functional group-containing monomer in the entire monomers forming the acrylic oligomer can be, for instance, 1 % by weight or greater, 2 % by weight or greater, or 3 % by weight or greater. It can also be, for instance, 15 % by weight or less, 10 % by weight or less, or 7 % by weight or less. These functional group-containing monomers may not be used in the acrylic oligomer.

[0107]

Examples of favorable acrylic oligomers include homopolymers of various monomers such as dicyclopentanyl methacrylate (DCPMA), cyclohexyl methacrylate (CHMA), isobornyl methacrylate (IBXMA), isobornyl acrylate (IBXA), dicyclopentanyl acrylate (DCPA), 1-adamantyl methacrylate (ADMA) and 1-adamantyl acrylate (ADA) as well as a copolymer of DCPMA and MMA, copolymer of DCPMA and IBXMA, copolymer of ADA and methyl methacrylate (MMA), copolymer of CHMA and isobutyl methacrylate (IBMA), copolymer of CHMA and IBXMA, copolymer of CHMA and acryloylmorpholine (ACMO), copolymer of CHMA and diethylacrylamide (DEAA), and copolymer of CHMA and AA.

[0108]

The acrylic oligomer can be formed by polymerizing its constituent monomers. The polymerization method and the polymerization conditions are not particularly limited. Various heretofore known polymerization methods (e.g. solution polymerization, emulsion polymerization, bulk polymerization, photopolymerization, radiation polymerization, etc.) can be employed under suitable conditions. The types of polymerization initiator (e.g. azo polymerization initiator) that can be used as necessary are essentially the same as those exemplified for the synthesis of the acrylic polymer (A). The amount of polymerization initiator and the amount of chain transfer agent (e.g. a mercaptan) used optionally are suitably selected based on common technical knowledge so as to obtain a desirable molecular weight. Thus, details are omitted.

[0109]

When the PSA layer or PSA composition includes an acrylic oligomer, the

amount included per 100 parts by weight of polymer (A) can be, for instance, 0.01 part by weight or greater. From the standpoint of obtaining greater effects, it can be 0.05 part by weight or greater, 0.1 part by weight or greater, or even 0.2 part by weight or greater. From the standpoint of the miscibility with the polymer (A), etc., the acrylic oligomer content per 100 parts by weight of acrylic polymer (A) is suitably below 50 parts by weight, preferably below 30 parts by weight, more preferably 25 parts by weight or less, for instance, possibly 10 parts by weight or less, 5 parts by weight or less, or even 1 part by weight or less. The PSA layer or PSA composition can be free of an acrylic oligomer.

[0110]

(Crosslinking agent)

In the PSA layer, a crosslinking agent can be used as necessary. In the art disclosed herein, the crosslinking agent is included typically in a crosslinked form in the PSA layer. The use of crosslinking agent allows suitable adjustment of the PSA layer's cohesive strength, etc. For instance, in the PSA layer comprising a photoactive monomer (B), the combined use of crosslinking agent and photoreactive monomer (B) can favorably bring about both flexibility in the PSA layer before photocuring of the photoreactive monomer and deformation resistance in the photocured PSA layer.

[0111]

The type of crosslinking agent is not particularly limited. Among heretofore known crosslinking agents, for instance, a choice can be made according to the composition of the PSA composition so that the crosslinking agent provides suitable crosslinking abilities in the PSA layer. Examples of usable crosslinking agents include isocyanate-based crosslinking agent, epoxy-based crosslinking agent, oxazoline-based crosslinking agent, aziridine-based crosslinking agent, carbodiimide-based crosslinking agent, melamine-based crosslinking agent, urea-based crosslinking agent, metal alkoxide-based crosslinking agent, metal chelate-based crosslinking agent, metal salt-based crosslinking agents, hydrazine-based crosslinking agent, and amine-based crosslinking agent. These can be used solely as one species or in a combination of two or more species.

[0112]

As the isocyanate-based crosslinking agent, a bifunctional or higher polyfunctional isocyanate compound can be used. Examples include aromatic isocyanates such as tolylene diisocyanate, xylene diisocyanate, polymethylene polyphenyl diisocyanate, tris (p-isocyanatophenyl)thiophosphate, and diphenylmethane diisocyanate;

alicyclic isocyanates such as isophorone diisocyanate; and aliphatic isocyanates such as hexamethylene diisocyanate. Commercial products include isocyanate adducts such as trimethylolpropane/tolylene diisocyanate trimer adduct (trade name CORONATE L available from Tosoh Corporation), trimethylolpropane/hexamethylene diisocyanate trimer adduct (trade name CORONATE HL available from Tosoh Corporation), and isocyanurate of hexamethylene diisocyanate (trade name CORONATE HX available from Tosoh Corporation) and trimethylolpropane/xylylene diisocyanate adduct (product name TAKENATE D-110N available from Mitsui Chemicals, Inc.).

[0113]

As the epoxy-based crosslinking agent, a species having two or more epoxy groups per molecule can be used without particular limitations. A preferable epoxy-based crosslinking agent has 3 to 5 epoxy groups per molecule. Specific examples of the epoxy-based crosslinking agent include N,N,N',N'-tetraglycidyl-m-xylenediamine, 1,3-bis(N,N-diglycidylaminomethyl)cyclohexane, 1,6-hexanediol diglycidyl ether, polyethylene glycol diglycidyl ether, and polyglycerol polyglycidyl ether. Examples of commercial epoxy-based crosslinking agents include product names TETRAD-X and TETRAD-C available from Mitsubishi Gas Chemical Co., Inc.; product name EPICLON CR-5L available from DIC Corp.; product name DENACOL EX-512 available from Nagase ChemteX Corporation; and product name TEPIC-G available from Nissan Chemical Industries, Ltd.

[0114]

As the oxazoline-based crosslinking agent, a species having one or more oxazoline groups in one molecule can be used without particular limitations.

Examples of the aziridine-based crosslinking agent include trimethylolpropane tris[3-(1-aziridiny)propionate] and trimethylolpropane tris[3-(1-(2-methyl)aziridiny)propionate)].

As the carbodiimide-based crosslinking agent, a low molecular weight compound or a high molecular weight compound having two or more carbodiimide groups can be used.

[0115]

In some embodiments, a peroxide can also be used as the crosslinking agent. Examples of the peroxide include di(2-ethylhexyl) peroxydicarbonate, di(4-*t*-butylcyclohexyl) peroxydicarbonate, di-*sec*-butylperoxydicarbonate, *t*-butylperoxyneodecanoate, *t*-hexylperoxypivalate, *t*-butylperoxypivalate, dilauroyl

peroxide, di-n-octanoyl peroxide, 1,1,3,3-tetramethylbutylperoxyisobutyrate, and dibenzoyl peroxide. Among these, peroxides having particularly excellent crosslinking reaction efficiency include di(4-t-butylcyclohexyl) peroxydicarbonate, dilauroyl peroxide, and dibenzoyl peroxide. It is noted that when a peroxide is used as the polymerization initiator, the remaining peroxide unused in the polymerization reaction can be used for the crosslinking reaction. In this case, when the remaining peroxide is quantified and the proportion of peroxide is less than a prescribed amount, the peroxide can be added as necessary to obtain the prescribed amount. Peroxide can be quantified by the method described in Japanese Patent No. 4971517.

[0116]

When using a crosslinking agent, its amount used (when two or more crosslinking agents are included, the total amount thereof) is not particularly limited. From the standpoint of obtaining a PSA that exhibits well-balanced adhesive properties such as adhesive strength and cohesive strength, the crosslinking agent is used in an amount of suitably 5 parts by weight or less to 100 parts by weight of the polymer (A). It can be 3 parts by weight or less, 2 parts by weight or less, 1 part by weight or less, or even less than 1 part by weight. In an embodiment using a crosslinking agent and photoreactive monomer (B) in combination, from the standpoint of making it easier to favorably obtain the effect of the combined use, the amount of crosslinking agent used per 100 parts by weight of polymer (A) can be, for instance, 0.80 part by weight or less, 0.60 part by weight or less, 0.30 part by weight or less, or even 0.10 part by weight or less. The minimum amount of crosslinking agent used is not particularly limited and it can be used in an amount above 0 part by weight to 100 parts by weight of polymer (A). In some embodiments, the amount of crosslinking agent used per 100 parts by weight of polymer (A) can be, for instance, 0.001 part by weight or greater, 0.01 part by weight or greater, or even 0.03 part by weight or greater.

[0117]

The art disclosed herein can be preferably implemented in an embodiment using at least an isocyanate-based crosslinking agent as the crosslinking agent. An isocyanate-based crosslinking agent can also be used in combination with another crosslinking agent. In an embodiment using an isocyanate-based crosslinking agent, the amount of isocyanate-based crosslinking agent used per 100 parts by weight of polymer (A) can be, for instance, 0.005 part by weight or greater, 0.01 part by weight or greater, or even 0.03

part by weight or greater. The amount of isocyanate-based crosslinking agent used per 100 parts by weight of polymer (A) can be, for instance, 10 parts by weight or less, 5 parts by weight or less, 3 parts by weight or less, below 2 parts by weight, below 1 part by weight, below 0.80 part by weight, below 0.60 part by weight, below 0.30 part by weight, below 0.10 part by weight, or even below 0.08 part by weight.

[0118]

To allow an aforementioned crosslinking reaction to proceed effectively, a crosslinking catalyst may be used. Examples of the crosslinking catalyst include metal-based crosslinking catalysts such as tetra-n-butyl titanate, tetraisopropyl titanate, ferric acetylacetonate, butyltin oxide, and dioctyltin dilaurate. In particular, a tin-based crosslinking catalyst such as dioctyltin dilaurate is preferable. The amount of crosslinking catalyst used is not particularly limited. To 100 parts by weight of the polymer (A), the amount of crosslinking catalyst used can be, for instance, about 0.0001 part or greater, about 0.001 part or greater, about 0.005 part by weight or greater, etc.; and it can be about 1 part by weight or less, about 0.1 part by weight or less, about 0.05 part by weight or less, etc.

[0119]

If desired, the PSA composition used for forming the PSA layer can include, as a crosslinking retarder, a keto-enol tautomeric compound. For instance, in a PSA composition including an isocyanate-based crosslinking agent or a PSA composition potentially used upon addition of isocyanate-based crosslinking agent, a keto-enol tautomeric compound can be preferably used. This can be effective in extending the PSA composition's pot life.

As the keto-enol tautomeric compound, various β -dicarbonyl compounds can be used. Specific examples include β -diketones such as acetylacetone and 2,4-hexanedione; acetoacetates such as methyl acetoacetate and ethyl acetoacetate; propionylacetates such as ethyl propionylacetate; isobutyrylacetates such as ethyl isobutyrylacetate; and malonates such as methyl malonate and ethyl malonate. Particularly favorable compounds include acetylacetone and acetoacetates. For the keto-enol tautomeric compound, solely one species or a combination of two or more species can be used.

The amount of the keto-enol tautomeric compound used to 100 parts by weight of the polymer (A) can be, for instance, 0.1 part by weight or greater and 20 parts by weight or less, suitably 0.5 part by weight or greater and 15 parts by weight or less, for instance,

possibly 1 part by weight or greater and 10 parts by weight or less, or even 1 part by weight or greater and 5 parts by weight or less.

[0120]

(Silane coupling agent)

The PSA layer disclosed herein can include a silane coupling agent if desired. The use of silane coupling agent can increase the PSA layer's peel strength to an adherend (e.g. a glass plate). The silane coupling agent-containing PSA layer can be favorably formed using a PSA composition comprising the silane coupling agent. From the standpoint of reducing gelation, etc., the PSA composition preferably includes the silane coupling agent in the free form. In some embodiments, the PSA layer disclosed herein preferably includes the silane coupling agent in the free form. Such free form silane coupling agent in the PSA layer can effectively contribute to an increase in peel strength. It is noted that the "free form" here means that the silane coupling agent is not chemically bonded to another component in the PSA composition or PSA layer.

[0121]

Examples of the silane coupling agent include silicon compounds having an epoxy structure such as 3-glycidoxypropyltrimethoxysilane, 3-glycidoxypropylmethyldimethoxysilane and 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane; amino group-containing silicon compounds such as 3-aminopropyltrimethoxysilane, N-(2-aminoethyl)3-aminopropyltrimethoxysilane and N-(2-aminoethyl) 3-aminopropylmethyldimethoxysilane; 3-chloropropyltrimethoxysilane; acetoacetyl group-containing trimethoxysilane; (meth)acrylate group-containing silane coupling agents such as 3-acryloxypropyltrimethoxysilane, and 3-methacryloxypropyltriethoxysilane; and isocyanate group-containing silane coupling agents such as 3-isocyanatopropyltriethoxysilane. Particularly preferable examples include 3-glycidoxypropyltrimethoxysilane and acetoacetyl group-containing trimethoxysilane.

[0122]

When using a silane coupling agent, the amount used can be selected to obtain desirable effect from the use and is not particularly limited. In some embodiments, the amount of silane coupling agent used per 100 parts by weight of polymer (A) can be, for instance, 0.001 part by weight or greater. From the standpoint of obtaining greater effects, it can be 0.01 part by weight or greater, 0.05 part by weight or greater, or even 0.1

part by weight or greater. From the standpoint of reducing gelation of the PSA composition, etc., the amount of silane coupling agent used per 100 parts by weight of polymer (A) is suitably 3 parts by weight or less, possibly 1 part by weight or less, or even 0.5 part by weight or less.

[0123]

(Photopolymerization initiator)

The PSA layer disclosed herein can include a photopolymerization initiator as necessary for purposes such as enhancing or providing photocuring properties. As the photopolymerization initiator, similar to the photopolymerization initiators exemplified as usable species in the synthesis of polymer (A), it is possible to use ketal-based photopolymerization initiators, acetophenone-based photopolymerization initiators, benzoin ether-based photopolymerization initiators, acylphosphine oxide-based photopolymerization initiators, α -ketol photopolymerization initiators, aromatic sulphonyl chloride-based photopolymerization initiators, photoactive oxime-based photopolymerization initiators, benzoin-based photopolymerization initiators, benzylic photopolymerization initiators, benzophenone-based photopolymerization initiators, thioxanthone-based photopolymerization initiators, etc. For the photopolymerization initiator, solely one species or a combination of two or more species can be used.

[0124]

Specific examples of ketal-based photopolymerization initiators include 2,2-dimethoxy-1,2-diphenylethane-1-one.

Specific examples of acetophenone-based photopolymerization initiators include 1-hydroxycyclohexyl phenyl ketone, 4-phenoxydichloroacetophenone, 4-*t*-butyl-dichloroacetophenone, 1-[4-(2-hydroxyethoxy)-phenyl]-2-hydroxy-2-methyl-1-propane-1-one, 2-hydroxy-2-methyl-1-phenyl-propane-1-one and methoxyacetophenone

Specific examples of benzoin ether-based photopolymerization initiators include benzoin ethers such as benzoin methyl ether, benzoin ethyl ether, benzoin propyl ether, benzoin isopropyl ether and benzoin isobutyl ether as well as substituted benzoin ethers such as anisole methyl ether.

Specific examples of acylphosphine oxide-based photopolymerization initiators include bis(2,4,6-trimethylbenzoyl)phenylphosphine oxide, bis(2,4,6-trimethylbenzoyl)-2,4-di-*n*-butoxyphenylphosphine oxide, 2,4,6-trimethylbenzoyldiphenylphosphine oxide and bis(2,6-dimethoxybenzoyl)-2,4,4-trimethylpentylphosphine oxide.

Specific examples of α -ketol-based photopolymerization initiators include 2-methyl-2-hydroxypropiophenone and 1-[4-(2-hydroxyethyl)phenyl]-2-methylpropane-1-one. Specific examples of aromatic sulfonyl chloride-based photopolymerization initiators include 2-naphthalenesulfonyl chloride. Specific examples of photoactive oxime-based photopolymerization initiators include 1-phenyl-1,1-propanedione-2-(*o*-ethoxycarbonyl)-oxime. Specific examples of benzoin-based photopolymerization initiators include benzoin. Specific examples of benzil-based photopolymerization initiators include benzil.

Specific examples of benzophenone-based photopolymerization initiators include benzophenone, benzoylbenzoic acid, 3,3'-dimethyl-4-methoxybenzophenone, polyvinylbenzophenone and α -hydroxycyclohexylphenylketone.

Specific examples of thioxanthone-based photopolymerization initiators include thioxanthone, 2-chlorothioxanthone, 2-methylthioxanthone, 2,4-dimethylthioxanthone, isopropylthioxanthone, 2,4-dichlorothioxanthone, 2,4-diethylthioxanthone, isopropylthioxanthone and 2,4-diisopropylthioxanthone, dodecylthioxanthone.

[0125]

The photopolymerization initiator content of the PSA layer is not particularly limited and can be selected to suitably obtain desirable effects. In some embodiments, the photopolymerization initiator content per 100 parts by weight of polymer (A) in the PSA layer is, for instance, possibly about 0.005 part by weight or greater, suitably 0.01 part by weight or greater, preferably 0.05 part by weight or greater, also possibly 0.10 part by weight or greater, 0.15 part by weight or greater, or even 0.20 part by weight or greater. With increasing photopolymerization initiator content, the photocuring properties of the PSA layer tend to increase. The photopolymerization initiator content per 100 parts by weight of polymer (A) is suitably 10 parts by weight or less, preferably 7 parts by weight or less, possibly 5 parts by weight or less, 3 parts by weight or less, 2 parts by weight or less, or even 1 part by weight or less. From the standpoint of increasing the storage stability (e.g. against photodegradation), it may be advantageous that the photopolymerization initiator content is not too much in excess.

[0126]

The PSA layer comprising a photopolymerization initiator can be typically formed using a PSA composition (e.g. a solvent-based PSA composition) comprising the photopolymerization initiator. The photopolymerization initiator-containing PSA composition can be prepared, for instance, by mixing the photopolymerization initiator

with other components used for the composition. When the PSA composition is prepared using a polymer (A) (e.g. an acrylic polymer (A)) synthesized (by photopolymerization) in the presence of a photopolymerization initiator, the remaining residue (unreacted residue) of the photopolymerization initiator used in synthesizing the polymer (A) can be used as part or all of photopolymerization initiator in the PSA layer. The same applies when using, as the acrylic oligomer used as necessary, a species synthesized in the presence of a photopolymerization initiator. From the standpoint of easy production management, the PSA layer disclosed herein can be preferably formed using a PSA composition prepared by freshly adding an aforementioned amount of photopolymerization initiator to other components.

[0127]

The PSA layer or the PSA composition disclosed herein may include, as necessary, various additives generally used in the field of PSA as other optional components, such as a tackifier resin (e.g. rosin-based, petroleum-based, terpene-based, phenolic and ketone-based tackifier resins, etc.), viscosity-adjusting agent (e.g. thickener), leveling agent, plasticizer, filler, colorant including pigment and dye, etc., stabilizing agent, preservative, anti-aging agent, and so on. With respect to these various additives, those heretofore known can be used according to typical methods. Since these do not particularly characterize the present invention, details are omitted.

The art disclosed herein can bring about good adhesive strength without using the tackifier resin. Thus, in some embodiments, in the PSA layer or PSA composition, the tackifier resin content per 100 parts by weight of polymer (A) can be, for instance, below 10 parts by weight, or even below 5 parts by weight. The tackifier resin content can also be below 1 part by weight (e.g. below 0.5 part by weight), or below 0.1 part by weight (0 part by weight or greater and below 0.1 part by weight). The PSA layer or PSA composition may be free of a tackifier resin.

[0128]

From the standpoint of the transparency, the PSA layer (and further the PSA composition used for forming the PSA layer) is preferably limited in amount(s) of other component(s) besides the polymer (A) and the photoreactive monomer (B) which is used as necessary. In the art disclosed herein, the amount of other component(s) besides the polymer (A) and photoreactive monomer (B) in the PSA layer is about 30 % by weight or less, suitably about 15 % by weight or less, or preferably about 12 % by weight or less (e.g.

about 10 % by weight or less). In some embodiments, the amount of other component(s) besides the polymer (A) and photoreactive monomer (B) in the PSA layer can be about 5 % by weight or less, about 3 % by weight or less, or even about 1.5 % by weight or less (e.g. about 1 % by weight or less).

[0129]

<Form of PSA composition>

The PSA layer in the art disclosed herein can be formed with a PSA composition that comprises monomeric components in a composition as described above as a polymerized product, in a non-polymerized form (i.e. in a form where the polymerizable functional groups are still unreacted), or as a mixture of these. The PSA composition may be in various forms such as a solvent-based PSA composition which comprises PSA (adhesive components) in an organic solvent; an aqueous PSA composition which comprises PSA dispersed in an aqueous solvent; an active energy ray-curable PSA composition prepared so as to form PSA when cured with active energy rays such as UV rays and radioactive rays; a hot melt-type PSA composition which is heated to melting for application and allowed to cool to around room temperature to form PSA; and the like. From the standpoint of the ease of preparing the PSA composition, ease of forming the PSA layer, etc., in some embodiments, solvent-based PSA compositions can be preferably used. A solvent-based PSA composition can be preferably prepared, using the polymer (A) which is a polymer produced by solution polymerization of the monomers.

[0130]

As used herein, the term “active energy ray” refers to an energy ray having energy capable of causing a chemical reaction such as polymerization, crosslinking and initiator decomposition. Examples of the active energy ray here include light such as ultraviolet (UV) rays, visible light, infrared light, radioactive rays such as α rays, β rays, γ rays, electron beam, neutron radiation and X rays.

[0131]

The PSA composition typically comprises at least some of the monomeric components (possibly a certain species among the monomers or a fraction of its quantity) as a polymer. The polymerization method for forming the polymer is not particularly limited. Heretofore known various polymerization methods can be suitably used. For instance, thermal polymerization (typically carried out in the presence of a thermal polymerization initiator) such as solution polymerization, emulsion polymerization and

bulk polymerization; photopolymerization carried out by irradiating light such as UV light (typically in the presence of a photopolymerization initiator); active energy ray polymerization carried out by irradiating radioactive rays such as β rays and γ rays; and the like. In these polymerization methods, the embodiment of polymerization is not particularly limited. It can be carried out with a suitable selection of a heretofore known monomer supply method, polymerization conditions (temperature, time, pressure, irradiance of light, irradiance of radioactive rays, etc.), materials (polymerization initiator, surfactant, etc.) used besides the monomers, etc.

[0132]

For the polymerization, depending on the polymerization method and embodiment of polymerization, etc., a known or commonly used photopolymerization initiator or thermal polymerization initiator can be used. Examples of photopolymerization initiators and thermal polymerization initiators are as described above and redundant particulars are omitted. These polymerization initiators can be used singly as one species or in a suitable combination of two or more species.

[0133]

(PSA Composition Comprising Polymerized and Non-Polymerized (Unreacted) Monomeric Components)

The PSA composition according to some embodiments comprises a polymerization product of a monomer mixture comprising at least some of the monomeric components (starting monomers) that constitute the composition. Typically, of the monomeric components, some are included as a polymerized product and the rest are included as unreacted monomers. The polymerization product of the monomer mixture can be prepared by polymerizing the monomer mixture at least partially.

The polymerization product is preferably a partially-polymerized product of the monomer mixture. Such a partially-polymerized product is a mixture of a polymer formed from the monomer mixture and unreacted monomers, and is typically in a form of syrup (viscous liquid). Hereinafter, a partially-polymerized product having such a form may be referred to as “monomer syrup,” “polymer syrup” or simply “syrup.”

[0134]

The polymerization method for obtaining the polymerization product from the monomers is not particularly limited. A suitable method can be selected and employed among various polymerization methods as those described earlier. From the standpoint

of the efficiency and convenience, a photopolymerization method can be preferably employed. According to a photopolymerization, depending on the polymerization conditions such as irradiation light quantity, etc., the polymer conversion of the monomer mixture can be easily controlled.

[0135]

With respect to the partially-polymerized product, the monomer conversion of the monomer mixture is not particularly limited. The monomer conversion can be, for instance, about 70 % by weight or lower, or preferably about 60 % by weight or lower. From the standpoint of facile preparation of the PSA composition comprising the partially-polymerized product and ease of application, etc., the monomer conversion is usually suitably about 50 % by weight or lower, or preferably about 40 % by weight or lower (e.g. about 35 % by weight or lower). The lower limit of monomer conversion is not particularly limited. It is typically about 1 % by weight or higher, or usually suitably about 5 % by weight or higher.

[0136]

The PSA composition comprising a partially-polymerized product of the monomer mixture can be easily obtained, for instance, by partially polymerizing a monomer mixture comprising all the starting monomers in accordance with a suitable polymerization method (e.g. photopolymerization). To the PSA composition comprising the partially-polymerized product, other components (e.g. photopolymerization initiator, polyfunctional monomer(s), crosslinking agent, acrylic oligomer described later, etc.) may be added as necessary. Methods for adding such other components are not particularly limited. For instance, they can be added to the monomer mixture in advance or added to the partially-polymerized product.

[0137]

The PSA composition disclosed herein may also be in a form where a fully-polymerized product of a monomer mixture comprising certain species (starting monomers) among the monomeric components is dissolved in the rest of the monomers (unreacted) or a partially-polymerized product thereof. A PSA composition in such a form is also included in examples of the PSA composition comprising polymerized and non-polymerized (unreacted) monomeric components. As used herein, the term “fully-polymerized product” refers to a product whose monomer conversion is higher than 95 % by weight.

[0138]

When forming PSA from a PSA composition comprising polymerized and non-polymerized monomeric components, a photopolymerization method can be preferably employed as the curing method (polymerization method). With respect to a PSA composition comprising a polymerization product prepared by a photopolymerization method, it is particularly preferable to employ photopolymerization as the curing method. A polymerization product obtained by photopolymerization already contains a photopolymerization initiator. When the PSA composition comprising the polymerization product is cured to form PSA, the photo-curing can be carried out without any additional photopolymerization initiator. Alternatively, the PSA composition may be obtained by adding a photopolymerization initiator as necessary to the polymerization product prepared by photopolymerization. The additional photopolymerization initiator may be the same as or different from the photopolymerization initiator used in preparing the polymerization product. If the PSA composition is prepared by a method other than photopolymerization, a photopolymerization initiator can be added to make it light-curable. The light-curable PSA composition is advantageous as it can readily form even a thick PSA layer. In a preferable embodiment, the PSA composition can be photopolymerized by UV irradiation to form a PSA. The UV irradiation may be performed using a commonly-known high-pressure mercury lamp, low-pressure mercury lamp, metal halide lamp, or the like.

[0139]

(PSA Composition Comprising Monomeric Components in a Fully-Polymerized Form)

The PSA composition according to another preferable embodiment comprises the monomeric components as a fully-polymerized product. Such a PSA composition may be in a form of, for instance, a solvent-based composition which comprises in an organic solvent an acrylic polymer which is the fully-polymerized product of the monomeric components, a water-dispersed composition such that the acrylic polymer is dispersed in an aqueous solvent, etc.

[0140]

(Formation of PSA layer)

The method for producing the PSA layer is not particularly limited. For instance, the PSA composition can be applied to the release face of a release film, allowing it to dry (e.g. with heat) or cure to form a PSA layer on the release face. Alternatively, the

PSA composition can be placed between two release films and allowed to dry or cure to form a PSA layer. The curing process may include crosslinking (e.g. crosslinking by reaction of an aforementioned crosslinking agent) and cooling. When performing two or more different curing processes, these can be carried out simultaneously or stepwise. The PSA composition can be applied by various known methods. Specific examples include methods such as roll coating, kiss roll coating, gravure coating, reverse coating, roll brush coating, spray coating, dip roll coating, bar coating, knife coating, air knife coating, curtain coating, lip coating, and extrusion coating with a die coater or the like. With the use of a release film having a highly smooth release face having a maximum height (Rz) and arithmetic mean roughness (Ra) typically limited to up to prescribed values, highly smooth adhesive faces can be consistently (reproducibly) produced. The PSA composition is applied preferably at or below 80 °C, or more preferably at or below 60 °C (e.g. at or below 40 °C). This can inhibit roughening of the PSA layer caused by a difference in coefficient of thermal expansion between the first release film or second release film and the PSA layer, allowing formation of a yet smoother adhesive face.

[0141]

(Thickness of PSA layer)

The thickness of the PSA layer is not particularly limited. The PSA layer's thickness can be, for instance, about 1 μm to 500 μm and it can be, for instance, about 3 μm to 500 μm . In some embodiments, the PSA layer's thickness is suitably 5 μm or greater, for instance, possibly 10 μm or greater, preferably 20 μm or greater, more preferably 25 μm or greater, or possibly even greater than 25 μm . With increasing thickness of the PSA layer, the PSA layer tends to have a higher ability to distribute stress. This can advantageously contribute to reduction of optical distortion. In addition, thick PSA layers tend to have excellent contour-following properties and are likely to absorb deformations caused by foreign particles. Impact strength tends to improve as well. The art disclosed herein can be preferably implemented in an embodiment where the PSA layer has a thickness of, for instance, 30 μm or greater. The PSA layer's thickness can be 35 μm or greater, 40 μm or greater, 45 μm or greater, 50 μm or greater, 75 μm or greater, or even 90 μm or greater. On the other hand, with increasing thickness of the PSA layer, the optical path in the PSA layer also increases in length; and therefore, optical distortion is more likely to be noticed. Thus, in some embodiments, the PSA layer's thickness is suitably, for instance, 200 μm or less, possibly 150 μm or less, 120 μm

or less, preferably 100 μm or less, more preferably 70 μm or less, yet more preferably 50 μm or less, or possibly even 35 μm or less. In the PSA layer having such a thickness, deformation of the PSA layer may be better inhibited. According to the art disclosed herein, highly deformation-resistant and highly impact-resistant bonding can be formed in an embodiment having a PSA layer that has a thickness of, for instance, 70 μm or less. The PSA layer's thickness can be measured with a 1/1000 mm scale dial gauge with a flat probe.

[0142]

(Tan δ peak temperature)

The PSA forming the PSA layer disclosed herein preferably has a loss tangent tan δ peak temperature in the range between $-50\text{ }^{\circ}\text{C}$ and $0\text{ }^{\circ}\text{C}$. With the PSA having a tan δ peak in a low temperature range, good impact resistance is likely obtained. The PSA's loss tangent tan δ peak temperature can be determined by the following method: Under the same conditions as the 25°C storage modulus analysis described below, mechanical viscoelastic analysis is carried out to determine the storage modulus G' and loss modulus G'' . Subsequently, the loss tangent tan δ is determined by the next equation $\tan \delta = G''/G'$ and its temperature dependence can be plotted to determine the temperature corresponding to the peak (the temperature at which the tan δ peak occurs (the tan δ curve maximizes)).

[0143]

(25°C storage modulus)

The PSA layer's storage modulus at $25\text{ }^{\circ}\text{C}$ (25°C storage modulus) is suitably selected in accordance with the purpose, usage, etc., and is not particularly limited to a specific range. From the standpoint of the heat resistance and adhesive properties such as deformation resistance, etc., the 25°C storage modulus is suitably about $4 \times 10^4\text{ Pa}$ or greater, preferably about $6 \times 10^4\text{ Pa}$ or greater, more preferably about $8 \times 10^4\text{ Pa}$ or greater, possibly about $1.0 \times 10^5\text{ Pa}$ or greater, about $1.2 \times 10^5\text{ Pa}$ or greater, about $1.5 \times 10^5\text{ Pa}$ or greater, or even about $1.8 \times 10^5\text{ Pa}$ or greater. PSA layers having high 25°C storage moduli tend to have excellent resistance to depressed deformation. The $25\text{ }^{\circ}\text{C}$ storage modulus is, for instance, below $1 \times 10^7\text{ Pa}$, or suitably about $1 \times 10^6\text{ Pa}$ or less. From the standpoint of favorably bringing about adhesive properties such as adhesion, the 25°C storage modulus is preferably about $5.0 \times 10^5\text{ Pa}$ or less, more preferably about $3.0 \times 10^5\text{ Pa}$ or less, yet more preferably about $2.0 \times 10^5\text{ Pa}$ or less, possibly about 1.4×10^5

Pa or less, or even about 1.0×10^5 Pa or less. The 25°C storage modulus can be adjusted through the base polymer's molecular weight, molecular structure, concentration, crosslinking degree, etc. The 25°C storage modulus is determined by the method described below. The same applies in the working examples described later.

[0144]

[25°C Storage modulus]

Several layers of the PSA layer subject to analysis are layered to fabricate an approximately 2 mm thick PSA layer. Of the resulting PSA layer, a 7.9 mm diameter disc is punched out. The disc-shaped specimen is fastened and secured between parallel plates; and with a rheometer (e.g. ARES available from TA Instruments or a comparable product), mechanical viscoelastic analysis is carried out under the conditions shown below to determine the 25°C storage modulus $G'(25^\circ\text{C})$ (Pa).

- Measurement mode: shear mode
- Temperature range: -70 °C to 150 °C
- Heating rate: 5 °C/min
- Measurement frequency: 1 Hz

[0145]

(Gel fraction)

The PSA layer's gel fraction is suitably selected in accordance with the purpose, usage, etc., and is not limited to a specific range. The gel fraction is, for instance, about 99 % by weight or lower, or suitably about 97 % by weight or lower. From the standpoint of the contour-following properties, in some embodiments, the gel fraction is about 95 % by weight or lower, more preferably about 92 % by weight or lower, possibly about 88 % by weight or lower, about 75 % by weight or lower, or even about 65 % by weight or lower. When the adherend surface has some print such as a logo mark, the PSA sheet having such a gel fraction can conform well to the print's contours without impairing the visibility. From the standpoint of obtaining good adhesive properties and viscoelastic properties, the PSA layer's gel fraction is, for instance, 10 % by weight or higher, or suitably about 20 % by weight or higher. From the standpoint of the deformation resistance, etc., the gel fraction is preferably about 30 % by weight or higher, more preferably about 40 % by weight or higher, possibly about 50 % by weight or higher, about 65 % by weight or higher, or even about 75 % by weight or higher. The gel fraction can be adjusted through the base polymer's molecular weight, molecular structure,

concentration, crosslinking degree, etc. The gel fraction is determined by the method described below. The same applies in the working examples described later.

[0146]

[Gel fraction]

A prescribed amount of PSA sample (weight: W_{g1}) is wrapped into a pouch with a porous polytetrafluoroethylene membrane (weight: W_{g2} ; mean pore diameter 0.2 μm), and the opening is tied with twine (weight: W_{g3}). As the porous polytetrafluoroethylene (PTFE) membrane, product name NITOFOLON® NTF1122 (0.2 μm mean pore diameter, 75 % porosity, 85 μm thick) available from Nitto Denko Corporation or an equivalent product is used.

The resulting pouch is immersed in a sufficient volume of ethyl acetate and stored at room temperature (typically 23 °C) for 7 days to extract the sol fraction of the PSA layer out of the membrane. Subsequently, the pouch is collected, and any residual ethyl acetate is wiped off the outer surface. The pouch is dried at 130 °C for 2 hours and the pouch's weight (W_{g4}) is determined. The gel fraction of the PSA layer is determined by substituting the respective values into the next equation:

$$\text{Gel Fraction (\%)} = [(W_{g4} - W_{g2} - W_{g3}) / W_{g1}] \times 100$$

[0147]

(Total light transmittance)

In some embodiments, the PSA layer has a total light transmittance of, for instance, about 50 % or higher, or suitably, for instance, about 70 % or higher. From the standpoint of the decorative film visibility through the PSA layer, in some preferable embodiments, the total light transmittance of the PSA layer is about 85 % or higher, or more preferably about 90 % or higher. The maximum total light transmittance is theoretically the value obtained by subtracting from 100 % the optical loss (Fresnel loss) due to reflection occurring at the interface with air. For practical use, it can be about 95 % or lower, or even about 94 % or lower (e.g. 93 % or lower). Even when the PSA layer has such a total light transmittance, good visibility can be obtained through the PSA layer.

[0148]

(Haze value)

In some embodiments, the PSA layer has a haze value of, for instance, about 10 % or lower, suitably about 3 % or lower. From the standpoint of the visibility through the

PSA layer, in some preferable embodiments, the PSA layer has a haze value of about 1 % or lower, more preferably about 0.8 % or lower, or yet more preferably 0.5 % or lower. The minimum haze value is theoretically 0 % and can be above about 0.0 % for practical use.

[0149]

The PSA layer's total light transmittance and haze value can be adjusted through the composition (base polymer species, additives) and thickness of the PSA layer, etc.

[0150]

The PSA layer's total light transmittance and haze value can be determined, using a haze meter, on the PSA layer subject to measurement adhered onto one face of a glass plate. As the haze meter, it is possible to use system name HM-150N available from Murakami Color Research Laboratory Co., Ltd. or a comparable system. In particular, it is determined by the method described later in the working examples.

[0151]

The PSA layer having such total light transmittance and haze value can be a colored or colorless transparent PSA layer. As used herein, the term "transparent" is used, conceptually encompassing semi-transparent. The effect of the PSA layer according to the art disclosed herein to reduce optical distortion can be obtained in an embodiment where at least part of the PSA layer surface has a level of transparency that allows observation through the PSA layer; and therefore, the PSA layer is not required to be transparent or semi-transparent.

[0152]

(Surface properties of adhesive face)

The PSA layer disclosed herein preferably has an adhesive face (encompassing the first and second adhesive faces; the same applies hereinafter, unless otherwise noted) whose maximum height Rz is limited to up to a prescribed value. According to an embodiment having an adhesive face designed to have a low maximum height Rz, high surface smoothness can be obtained without or with reduced optical distortion. For instance, when the decorative film is observed through the PSA layer, such a PSA layer may not impair the adherend's design quality, for instance, beauty or luxury feel.

[0153]

The PSA layer's adhesive face has a maximum height Rz of, for instance, about 2000 nm or less, suitably about 1000 nm or less, preferably about 600 nm or less, more

preferably about 500 nm or less, yet more preferably about 450 nm or less, particularly preferably about 400 nm or less, possibly below 350 nm, below 300 nm, or even below 250 nm. From the standpoint of the efficiency of manufacturing, etc., in some embodiments, the PSA layer's adhesive face has a maximum height R_z of, for instance, possibly about 10 nm or greater, about 50 nm or greater, about 100 nm or greater, or even about 200 nm or greater. The maximum heights R_z of the PSA layer's first and second adhesive faces can be about the same or different.

[0154]

The adhesive face of the PSA layer disclosed herein preferably has an arithmetic mean roughness R_a limited to up to a prescribed value. According to an embodiment having an adhesive face designed to have a low arithmetic mean roughness R_a , optical distortion is likely to be greatly reduced.

[0155]

The PSA layer's adhesive face has an arithmetic mean roughness R_a of, for instance, about 300 nm or less, suitably about 150 nm or less, preferably about 70 nm or less, more preferably about 65 nm or less, yet more preferably about 55 nm or less, possibly below 50 nm, below 45 nm, or even below 40 nm. From the standpoint of the efficiency of manufacturing, etc., in some embodiments, the PSA sheet's adhesive face has an arithmetic mean roughness R_a of, for instance, possibly about 10 nm or greater, about 20 nm or greater, or even about 30 nm or greater (e.g. about 40 nm or greater). The arithmetic mean roughness R_a of the PSA layer's first and second adhesive faces can be about the same or different.

[0156]

The maximum height R_z and arithmetic mean roughness R_a of the PSA layer's adhesive face can be adjusted through the surface properties of the release film layered on the adhesive face, the release film's peel strength to the PSA layer, the PSA layer's thickness, etc.

[0157]

The maximum height R_z and arithmetic mean roughness R_a of the PSA layer's adhesive face can be determined on the adhesive face of the PSA layer after the release film is removed from the release film-bearing PSA sheet, using a non-contact surface roughness analyzer. As the non-contact surface roughness analyzer, an optical interferometric surface roughness analyzer is used. For instance, a 3D optical profiler

(product name NewView 7300 available from ZYGO Corporation) or a comparable product can be used. Specific operations and conditions of the measurement can be set according to the measurement conditions described later in the working examples or to obtain data equivalent or comparable to data obtained according to the measurement conditions.

[0158]

(Adhesive strength to transparent member)

The adhesive strength of the PSA layer disclosed herein is not particularly limited and can be selected in accordance with the purpose. In some embodiments, the PSA layer has an adhesive strength to transparent member of, for instance, suitably about 1.0 N/20mm or greater, or possibly about 3.0 N/20mm or greater (e.g. about 5.0 N/20mm or greater). In other words, the PSA layer is bonded to the transparent member with such an adhesive strength. When the transparent member and PSA layer are so tightly bonded, the laminate can exhibit great endurance against impact, etc. From the standpoint of the bonding reliability, the to-glass adhesive strength is preferably about 7.0 N/20mm or greater, more preferably about 8.0 N/20mm or greater, yet more preferably about 9.0 N/20mm or greater, possibly about 10.0 N/20mm or greater, or even about 11.0 N/20mm or greater. For instance, the PSA sheet having such a to-glass adhesive strength can be preferably used for purposes such as bonding and fixing parts. From the standpoint of readily achieving a balance with other properties, the to-glass adhesive strength can be, for instance, about 20 N/20mm or less, about 16.0 N/20mm or less, or even about 12.0 N/20mm or less. The to-glass adhesive strength can be adjusted through selections of PSA layer's composition, thickness, etc.

[0159]

The adhesive strength to transparent member is determined as follows: The adhesive face subject to measurement is press-bonded to a transparent member (e.g. a glass plate) by rolling a 2 kg rubber roller back and forth once; and in an environment at 23 °C and 50 %RH, using a tensile tester, based on JIS Z 0237, the peel strength is measured while the PSA layer is peeled from the transparent member at a peel angle of 180° at a tensile speed of 300 mm/min. In particular, it is determined by the method described later in the working examples.

[0160]

(Elastic modulus by tensile test)

In some preferable embodiments, the PSA layer has an elastic modulus (or initial elastic modulus) of 3.0 MPa or greater by a tensile test. PSA layers with higher elastic moduli tend to show superior deformation resistance. In an embodiment of the laminate wherein two members (typically a transparent member and decorative film) are bonded together via a PSA layer, the high deformation resistance of the PSA layer may be useful in precisely maintaining the relative positions of the two members. In an embodiment where, for instance, a decorative film and transparent member are bonded together via a PSA layer, the high deformation resistance of the PSA layer may be useful in reducing the occurrence of changes in appearance of the laminate when locally pressed on the decorative film side (resistance to depressed deformation).

[0161]

In the PSA layer according to preferable embodiments, the elastic modulus can be, for instance, 5.0 MPa or greater, 7.0 MPa or greater, 10.0 MPa or greater, 15.0 MPa or greater, or even 20.0 MPa or greater. With increasing elastic modulus, the deformation resistance tends to increase. The maximum elastic modulus is not particularly limited. From the standpoint of readily achieving a balance with other properties (e.g. one, two or more properties selected among the impact strength, to-glass adhesive strength, haze value, etc.), the elastic modulus is advantageously 150 MPa or less, preferably 120 MPa or less, possibly 100 MPa or less, 80 MPa or less, or even 60 MPa or less. The elastic modulus by the tensile test can be adjusted through selections of composition of the PSA layer, etc. The elastic modulus is determined by the tensile test described above. More specifically, it is determined by the method described later in the working examples.

[0162]

(Impact strength)

The PSA layer disclosed herein preferably has an impact strength of 2.0 J/10mm² or greater. The PSA layer having a high impact strength can form a highly reliable bonding. For instance, this can be an advantageous feature in the PSA layer used for bonding and fixing members, etc. For instance, even upon impact of falling, collision, etc., such a PSA layer can endure the impact to well maintain the bonded state in the laminate.

[0163]

In the PSA layer according to preferable embodiments, the impact strength can be, for instance, 2.1 J/10mm² or greater, 2.3 J/10mm² or greater, 2.5 J/10mm² or greater,

2.7 J/10mm² or greater, or even 3.0 J/10mm² or greater. The PSA laminate disclosed herein can be preferably made in an embodiment where the PSA layer has an impact strength of 3.3 J/10mm² or greater, or 3.5 J/10mm² or greater. The maximum impact strength is not particularly limited. From the standpoint of readily achieving a balance with other properties, the impact strength can be, for instance, 20 J/10mm² or less, 15 J/10mm² or less, 10 J/10mm² or less, 8.0 J/10mm² or less, or even 6.0 J/10mm² or less. The impact strength can be adjusted through selections of PSA layer's composition, thickness, etc. The impact strength is determined by the shear impact test described earlier. More specifically, it is determined by the method described later in the working examples.

[0164]

The PSA layer disclosed herein includes an embodiment where it is allowed to photocure after applied to an adherend. Thus, at least with respect to a photocuring PSA layer (e.g. PSA C described later in the working examples), a measurement sample that has been irradiated with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm² and aged at 50 °C for 48 hours is used to determine the tan δ peak temperature, 25°C storage modulus, gel fraction, total light transmittance, haze value, adhesive face's maximum height Rz, arithmetic mean roughness Ra, adhesive strength, elastic modulus by tensile test, and impact strength. When the release film is transparent, the UV irradiation process is preferably carried out on the PSA layer placed between transparent release films.

[0165]

<Second PSA layer>

For instance, as shown in Fig. 4, the art disclosed herein can be implemented in an embodiment of the laminate comprising first and second PSA layers. The first PSA layer is placed between a transparent member and a decorative film. The second PSA layer is placed on the reverse side of the first PSA layer side of the decorative film. In such an embodiment, the first and second PSA layers may be the same or different in composition, configuration, properties, etc. The first and second PSA layers can be independently designed to have compositions, configurations, properties, etc., suited for the purpose and usage based on the description above. For instance, because of its location, the second PSA layer may not be required to have the level of visibility required for the first PSA layer and thus may have different composition, configuration and

properties from the first PSA layer. In accordance with the properties required for its location, etc., a known or commonly used PSA can be used as the second PSA layer.

[0166]

While no particular limitations are imposed, the second PSA layer may have a lower total light transmittance than the first PSA layer. The second PSA layer may also have a higher haze value than the first PSA layer. The second PSA layer may be a colored PSA layer (e.g. a black-colored PSA layer), serving as a colored layer. No particular limitations are imposed on the maximum height R_z or arithmetic mean roughness R_a of the adhesive face of the second PSA layer. They can be comparable to or higher than the maximum height R_z and arithmetic mean roughness R_a of the first adhesive face.

[0167]

In an embodiment of the laminate comprising the first and second PSA layer, the thickness of the second PSA layer is preferably designed to be larger than the thickness of the first PSA layer. In such an embodiment, for instance, deformation resistance including resistance to depressed deformation can be preferably obtained with the second PSA layer. This can increase the degrees of freedom in designing the first PSA layer placed on the visible side of the decorative film. For instance, the functionalities of the laminate at large can be preferably enhanced by, for instance, reducing optical distortion in the first PSA layer and improving deformation resistance in the second PSA layer. While no particular limitations are imposed, the second PSA layer's thickness can be 1.2 times (e.g. about 1.2 times to 5 times) the first PSA layer's thickness or greater, 1.5 times or greater, or even 2 times or greater.

[0168]

<Application of PSA layer>

The method for applying the PSA layer disclosed herein to an adherend is not particularly limited. A known or commonly used press-bonding method can be employed in accordance with the purpose and usage. In some preferable embodiments, the PSA layer can be used in an embodiment where it is applied by a method that includes allowing the PSA layer to photocure after applied to the adherend (specifically, a transparent member or decorative film). Upon application of the PSA layer to the adherend (specifically, a transparent member or decorative film), the laminate layered with the PSA layer is formed. By allowing the PSA layer to photocure, a laminate is

obtained, comprising the photocured PSA layer and the adherend (specifically, a transparent member or decorative film). Thus, the present Description provides a laminate production method, the method comprising, in the following order, applying a PSA layer disclosed herein to an adherend (specifically, a transparent member or decorative film), and subjecting the PSA layer to UV irradiation (e.g. through a transparent member) to photocure the PSA layer.

[0169]

<Laminate structure of transparent member and PSA layer>

(Total light transmittance)

In some embodiments, the laminate structure of transparent member and PSA layer is, for instance, about 50 % or higher, or suitably about 70 % or higher. From the standpoint of the decorative film visibility through the transparent member and PSA layer, in some preferable embodiments, the laminate structure has a total light transmittance of, about 85 % or higher, or more preferably about 90 % or higher. The maximum total light transmittance is theoretically the value obtained by subtracting from 100 % the optical loss (Fresnel loss) due to reflection occurring at the interface with air. For practical use, it can be about 95 % or lower. Even when it is about 94 % or lower (e.g. 92 % or lower), good visibility can be obtained through the transparent member and PSA layer.

[0170]

(Haze value)

In some embodiments, the laminate structure of transparent member and PSA layer has a haze value of, for instance, about 10 % or lower, or suitably about 3 % or lower. From the standpoint of the visibility through the transparent member and PSA layer, in some preferable embodiments, the laminate structure has a haze value of about 1 % or lower, more preferably about 0.8 % or lower, or yet more preferably 0.5 % or lower. The minimum haze value is theoretically 0 % and can be above about 0.0 % for practical use.

[0171]

The total light transmittance and haze value of the laminate of the transparent member and PSA layer can be determined using a haze meter. As the haze meter, model name HM-150N available from Murakami Color Research Laboratory Co., Ltd., or a comparable product can be used.

[0172]

<Decorative film>

The laminate disclosed herein comprises a decorative film. The decorative film here refers to a film whose surface (decorated face) has a design (including a color, color tone, pattern, and character information such as a logo mark; the same applied hereinafter). The decorative film includes a component that provides decoration and protection to image displays and input devices while maintaining their visibility. Examples of the decorative film include a film having a decoration layer (a print layer, laminate layer, colored layer, gloss layer, continuous or non-continuous inorganic layer (metal layer, metal oxide layer, etc.) to provide desirable appearances. The decorative film may provide good concealment while having design quality on the surface.

[0173]

The decorative film may have a decoration layer. Examples of the decoration layer include a print layer, laminate layer, colored layer, gloss layer, and continuous or non-continuous inorganic layer to provide desirable appearances. Examples of the continuous or non-continuous inorganic layer include a continuous or non-continuous metal layer, continuous or non-continuous metal oxide layer, continuous or noncontinuous laminate of metal and metal oxide layers, and continuous or non-continuous metal/metal oxide composite layer. Examples of the metal include aluminum, zinc, lead, copper, silver and alloys thereof. Examples of the metal oxide include chromium oxide, indium oxide, zinc oxide, and titanium oxide. Metal layers and metal oxide layers can be formed by vapor deposition, sputtering, etc. A typical example of the decorative film is a metal-tone film. The metal-tone decorative film may have electromagnetic wave transmittance. Examples of such decorative films include electromagnetic wave-transmitting metallic luster members as those described in Japanese Patent Application Publications No. 2018-69462, No. 2019-123238 and No. 2019-188805.

[0174]

In particular, the decorative film may further have a substrate layer, and a decorative layer that at least partially covers at least one face of the substrate layer. As the substrate layer, various resin films can be used, such as the plastic films. Examples of the plastic film material include polyester-based resins such as polyethylene terephthalate (PET), polybutylene terephthalate (PBT) and polyethylene naphthalate

(PEN); polyolefinic resins such as polyethylene (PE), polypropylene (PP), ethylene-propylene copolymer and ethylene-butene copolymer; cellulose-based resins such as triacetyl cellulose; acetate-based resins; polysulfone-based resins; polyether sulfone-based resins; polycarbonate-based resins; polyamide-based resins; polyimide-based resins; cyclic polyolefin resins such as norbornene-based resins; (meth)acrylic resins; polyvinyl chloride-based resins; polyvinylidene chloride-based resins; polystyrene-based resins; polyvinyl alcohol-based resins; ethylene-vinyl acetate copolymer resins; ethylene-vinyl alcohol copolymer resins; polyarylate-based resins; and polyphenylene sulfide-based resins. Among them, a preferable resin film is formed from a polyester-based resin such as PET, polyolefinic resin, polycarbonate-based resin, or (meth)acrylic resin. The substrate layer's thickness is not particularly limited. It is, for instance, about 5 μm to 250 μm . The decorative layer can be placed on the PSA layer side of the substrate layer, on the reverse side of the PSA layer, or on each side of the substrate layer.

[0175]

In the decorative film comprising a decoration layer, the decoration layer has a thickness preferably in the range between about 1 nm and 1000 nm. For instance, it can be about 1 nm to 300 nm, or about 1 nm to 200 nm. The decoration layer has a sheet resistance of suitably 100 Ω/sq or greater, for instance, possibly 250 Ω/sq , or even 1000 Ω/sq . The decorative film having such a decoration layer may transmit radio waves; and therefore, it can be preferably used in various applications requiring radio wave transmission, for instance, portable electronic devices. The maximum sheet resistance of the decoration layer is not particularly limited and can be, for instance, $1 \times 10^{16} \Omega/\text{sq}$ or less. The sheet resistance can be determined based on the eddy current testing method described in JIS Z 2316. The same method is used for measurements in the working examples described later.

[0176]

From the standpoint of the concealing properties and light-blocking properties, the decorative film has a visible light transmittance of suitably below 30 %, possibly below 20 %, preferably below 10 %, or even 7.0 % or lower. The minimum visible light transmittance is 0 %, possibly 1 % or higher, or even 3 % or higher. The decorative film's visible light transmittance can be adjusted through the selected decoration layer of the decorative film, etc. The decorative film's visible light transmittance is determined by measuring the transmittance of the visible light range (380 nm to 780 nm) by a

spectrophotometer. The same method is used for measurements in the working examples described later.

[0177]

The designed face of the decorative film may have a flat surface or may have contours of print such as logo marks or engraved markings. The PSA layer disclosed herein may also have excellent contour-following properties. Thus, it may also tightly adhere to the contoured decorative film surface.

[0178]

The PSA layer side surface of the decorative film may be subjected to a surface treatment such as primer coating, corona discharge treatment and plasma treatment. These surface treatments may increase the tightness of adhesion between the decorative film and PSA layer.

[0179]

<Colored layer>

The laminate disclosed herein may include one, two or more colored layers. Each color layer may be placed at any location among the following: between the transparent member and PSA layer, between the PSA layer and decorative film, on the reverse side of the PSA layer side of the decorative film. The colored layer may be placed on the outer face of the transparent member. The laminate having a colored layer can bring about high concealing properties.

[0180]

The colored layer placed in the laminate is not particularly limited as long as it is colored. In some embodiments, the colored layer can be formed by applying a colored layer-forming composition comprising a colorant and binder onto the transparent member, PSA layer, or decorative film. As the colorant, heretofore known pigments and dyes can be used. The colorant may have a color of, for instance, black, gray, red, blue, yellow, green, yellow-green, orange, purple, gold, silver, pearl and white. Black-based colorants tend to have excellent light-blocking properties and also tend to have excellent visibility (including mechanical discrimination) and design quality. From the standpoint of obtaining excellent light-blocking properties, black-based colorants are preferably used. In such a case, the colored layer is also called a black-colored layer.

[0181]

As the black colorant, an organic or inorganic colorant (pigment, dye, etc.) can be

used. Specific examples of the black colorant include carbon black (furnace black, channel black, acetylene black, thermal black, lamp black, pine smoke, etc.), graphite, copper oxide, manganese dioxide, aniline black, perylene black, titanium black, cyanine black, activated carbon, ferrites (nonmagnetic ferrites, magnetic ferrites, etc.), magnetite, chromium oxide, iron oxide, molybdenum disulfide, chromium complexes, and anthraquinone-based colorants. Among them, carbon black is preferable.

[0182]

As the binder used in the colored layer, known materials in the fields of painting and printing can be used without particular limitations. Examples include polyurethane, phenol resin, epoxy resin, urea-melamine resin and polymethyl methacrylate. The colored layer-forming composition can be, for instance, a solvent-based type, UV-curable type, heat-curable type, etc. The colored layer can be formed by a method conventionally employed for forming colored layers without particular limitations. For instance, it is preferable to use a method where the colored layer (print layer) is formed by printing such as gravure printing, flexographic printing, and offset printing.

[0183]

The colored layer may have a monolayer structure formed entirely of a single layer or a multilayer structure including two, three or more colored sublayers. For instance, a colored layer having a multilayer structure with two or more colored sublayers can be formed by repeated applications (e.g. printing) of a colored layer-forming composition. The respective colored sublayers may be the same or different in color and amount of colorant. In a colored layer to provide light-blocking properties, from the standpoint of preventing formation of pinholes to increase the reliability of light leakage prevention, a multilayer structure is particularly significant.

[0184]

For instance, such a colored layer (possibly a print layer) can be formed entirely over the surface of the transparent member or decorative film, or can be partially formed on the surface. Print layers are suited for partial formation (coloration). For instance, in the laminates shown in Figs. 2 to 4, the colored layer (print layer) can be preferably used as a colored layer 40. In a top view, the partially disposed colored layer can be, for instance, character information, a design or pattern. It can be formed circularly along the edge (in a frame shape)

[0185]

In other embodiments, the colored layer is a resin film comprising a colorant. For instance, it can be a resin film formed with a colorant mixed in main components (resin materials) of the resin film. The colorant-containing resin film is also called a colored resin film. As the colorant in the resin film, heretofore known pigments and dyes exemplified above can be used. From the standpoint of the concealing properties, black colorants are preferable. Among them, carbon black is preferable. The colored layer is preferably a black-colored layer.

[0186]

The colored resin film may include, as necessary, various additives such as a filler (inorganic filler, organic filler, etc.), dispersing agent (surfactant, etc.), anti-aging agent, antioxidant, UV absorber, antistatic agent, slip agent and plasticizer.

[0187]

The colored resin film may have a monolayer structure or a multilayer structure including two, three or more layers. From the standpoint of the shape stability, etc., the resin film preferably has a monolayer structure. In case of a multilayer structure, it is preferable that at least one layer (preferably each layer) has a continuous structure of the resin (colorant-containing resin). For the method for producing the resin film, a heretofore known method can be suitably employed without particular limitations. For instance, a heretofore known general resin film formation method can be suitably employed, such as extrusion molding, inflation molding, T-die casting and calendar rolling.

[0188]

For instance, such a colored resin film layer can be preferably placed entirely over the surface on the reverse side of the PSA layer side of the decorative film. For instance, in the laminates shown in Figs. 3 and 4, the colored resin film layer (e.g. a black-colored resin film layer) can be preferably used as a colored layer 50.

[0189]

<Other layers>

Besides the transparent member, PSA layer and decorative film, the laminate disclosed herein can optionally have one, two or more additional layers in accordance with the purpose and usage. For instance, between the respective layers (transparent member, PSA layer, decorative film, colored layer, etc.), additional layers can be placed, such as a primer layer or easy adhesion layer to enhance the interlayer adhesion, UV-

absorbing layer and anti-blocking layer. The PSA layer side and reverse side of the transparent member can be provided with a hard coat layer, anti-glare layer, anti-dirt/anti-fingerprint layer, etc.

[0190]

<Applications>

The laminate disclosed herein is not limited to particular applications and can be used in various applications where a laminate having a transparent member and decorative film is applied. The laminate disclosed herein can be preferably used in a portable electronic device. For instance, in the portable electronic device, it can be preferably used as a laminate comprising a transparent case as the transparent member. According to such an embodiment, while the decorative film's decorated face can be observed from the outside of the case; for instance, in an embodiment having a colored layer, because it may be able to conceal the content, it may be particularly suitable as an exterior structure of a case, etc.

[0191]

Non-limiting examples of the mobile electronics include mobile phones, smartphones, tablet PCs, notebook PCs, various wearable devices (e.g. wrist wearables put on wrists such as wrist watches; modular devices attached to bodies with clips, straps, etc.; eye wears including eye glass types (monocular or binocular, including head-mounted pieces); clothing types worn as, for instance, accessories on shirts, socks, hats/caps, etc.; ear-mounted pieces put on ears such as earphones), digital cameras, digital video cameras, acoustic equipment (portable music players, IC recorders, etc.), calculators (e.g. pocket calculators), handheld game devices, electronic dictionaries, electronic notebooks, electronic books, vehicle navigation devices, portable radios, portable TVs, portable printers, portable scanners, and portable modems. In this description, to be "mobile (portable)," it is unsatisfactory to be simply capable of being carried. Instead, it indicates a level of mobility (portability) that allows for relatively easy carriage by hand of an individual (a typical adult).

[0192]

The matters disclosed by this Description include the following:

- (1) A laminate having a transparent member, a PSA layer and a decorative film arranged in this order.
- (2) The laminate according to (1) above, having a visible light transmittance below 10 %

in the layering direction (build direction or thickness direction) of the transparent member, the PSA layer and the decorative film.

(3) The laminate according to (1) or (2) above, wherein the PSA layer surface has an arithmetic mean roughness Ra of 70 nm or less and a maximum height Rz of 600 nm or less.

(4) The laminate according to any of (1) to (3) above, wherein the PSA layer has a total light transmittance of 85 % or higher and a haze value of 1 % or lower in its layering direction (thickness direction).

(5) The laminate according to any of (1) to (4) above, wherein the PSA layer has a storage modulus of 4×10^4 Pa or greater at 25 °C.

(6) The laminate according to any of (1) to (5) above, wherein the PSA layer is bonded to the transparent member with a 180° peel strength greater than 7 N/20mm.

(7) The laminate according to any of (1) to (6) above, wherein the PSA layer is an acrylic PSA layer.

(8) The laminate according to any of (1) to (7) above, wherein the PSA layer has an elastic modulus of 3.0 MPa or greater, determined by the tensile test described below:

[Tensile test]

The PSA layer is irradiated with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm² and allowed to age at 50 °C for 48 hours. Subsequently, the PSA layer is cut to a 10 mm wide, 150 mm long size to prepare a test piece. In an environment at 23 °C and 50 %RH, using a tensile tester, a tensile test is carried out on the test piece at a chuck distance of 120 mm at a tensile speed of 50 mm/min to obtain a stress-displacement curve. From the initial slope, the elastic modulus (MPa) is determined.

(9) The laminate according to any of (1) to (8) above, wherein the PSA layer has an impact strength of 2.0 J/10mm² or greater, determined by the shear impact test described below.

[Shear impact test]

The shear impact test is carried out using a pendulum-type shear impact tester for adhesive bonds based on JIS K 6855. A measurement sample is obtained by applying the first face of a 10 mm square piece of the PSA layer to the center of a 25 mm square chemically-reinforced glass plate (1.7 mm thick) and applying the second face thereof to the center of a 40 mm square stainless steel plate (SUS304BA plate); press-bonding them

under a 5 N load for 10 seconds; autoclaving the resultant (50 °C, 0.5 MPa, 15 min); irradiating it with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm²; and then allowing it to age at 50 °C for 48 hours.

The measurement sample is fastened with the stainless steel plate down. In an environment at 23 °C and 50 %RH, an outer circumferential side of the glass plate is struck with a hammer at a hammer energy of 2.75 J at a hammer speed of 3.5 m/s and the energy (J) absorbed during this is measured to determine the impact strength (J/10mm²).

(10) The laminate according to any of (1) to (9) above, wherein the PSA layer comprises a polymer (A) and a photoreactive monomer (B).

(11) The laminate according to (10) above, wherein the photoreactive monomer (B) comprises a compound B1 whose molecule has a ring structure and two or more ethylenically unsaturated groups, and the compound B1 has a molecular weight of 100 g/mol or higher per ethylenically unsaturated group.

(12) The laminate according to any of (1) to (11) above, wherein the decorative film has a substrate layer and a decoration layer covering at least part of at least one face of the substrate layer, with the decoration layer having a thickness in the range between 1 nm and 1000 nm.

(13) The laminate according to (12) above, wherein the decoration layer has a sheet resistance of 100 Ω/sq or greater.

(14) The laminate according to any of (1) to (13) above, wherein the transparent member has a rectilinear bend or a curvilinear arc in an arbitrary cross section in parallel with the layering direction (i.e. the cross section includes the layering direction) of the laminate, and the PSA layer and the decorative film are placed where the bend or the arc of the transparent member exists.

(15) The laminate according to any of (1) to (14) above, further having one, two or more colored layers, wherein

each of the one, two or more colored layers is placed at any location among the following: between the transparent member and the PSA layer, between the PSA layer and the decorative film, and on the reverse side of the PSA layer side of the decorative film.

(16) The laminate according to any of (1) to (15) above, used in a portable electronic device.

(17) The laminate according to any of (1) to (16) above, wherein the PSA layer has a gel fraction of 30 % to 95 % by weight.

(18) The laminate according to any of (1) to (17) above, wherein the PSA sheet has a thickness of 5 μm to 100 μm .

[0193]

(19) The laminate according to (11) above, wherein the compound B1 comprises, per molecule, at least one structure selected from the group consisting of a bisphenol A structure, bisphenol F structure and bisphenol E structure.

(20) The laminate according to (11) or (19) above, wherein the compound B1 comprises an aliphatic ring structure as the ring structure.

(21) The laminate according to any of (11), (19) or (20) above, wherein the compound B1 comprises, per molecule, at least one structure selected from the group consisting of a hydroxy group and amino groups.

(22) The laminate according to any of (11) and (19) to (21) above, wherein the compound B1 content of the PSA layer is 0.5 part by weight or greater and 60 parts by weight or less to 100 parts by weight of the polymer (A).

(23) The laminate according to any of (11) and (19) to (22) above, wherein the PSA layer comprises, as the photoreactive monomer (B), the compound B1 and a compound B2 whose molecule has two or more functional groups and is free of a ring structure.

(24) The laminate according to (23) above, wherein the compound B2 has a functional group equivalent weight smaller than that of the compound B1.

(25) The laminate according to any of (23) or (24) above, wherein the compound B2 has a functional group equivalent weight of 400 g/mol or less.

(26) The laminate according to any of (23) to (25) above, wherein the compound B2 content of the PSA layer is 25 parts by weight or less to 100 parts by weight of the polymer (A).

(27) The laminate according to any of (10), (11) and (19) to (26) above, wherein the photoreactive monomer (B) content of the PSA layer is 1 part by weight or greater and 80 parts by weight or less to 100 parts by weight of the polymer (A).

(28) The laminate according to any of (10), (11) and (19) to (27) above, wherein the polymer (A) is an acrylic polymer.

(29) The laminate according to (28) above, wherein the acrylic polymer is formed from monomers including a monomer having a N-containing ring.

(30) The laminate according to any of (10), (11) and (19) to (29) above, wherein the polymer (A) has a glass transition temperature of -45°C or higher and below 0°C .

(31) The laminate according to any of (1) to (30) above, wherein the PSA layer is crosslinked with a crosslinking agent.

(32) The laminate according to any of (1) to (31) above, wherein the PSA layer comprises a photopolymerization initiator.

(33) The laminate according to any of (1) to (32) above, wherein the PSA layer comprises a silane coupling agent.

EXAMPLES

[0194]

Several tested examples related to the present invention are described below, but the specific examples are not to limit the present invention. In the description below, "parts" and "%" are by weight unless otherwise specified.

[0195]

<Test methods>

[Total light transmittance and haze value]

From a release film-bearing PSA sheet (PSA layer), one release film is removed. The resultant is applied to a glass slide (product name White, Polished No. 1 available from Matsunami Glass Ind., Ltd.; 0.8-1.0 mm thick, 92 % total light transmittance, 0.2 % haze). Subsequently, the other release film is removed to prepare a test piece having a PSA sheet (PSA layer)/glass slide layer structure. With respect to the resulting test piece, the total light transmittance and haze value are measured using a haze meter (model name HM-150N available from Murakami Color Research Laboratory Co., Ltd.). The measurement shall be taken on the PSA sheet (PSA layer)-bearing glass plate placed with the PSA sheet (PSA layer) facing the light source.

[0196]

[To-glass adhesive strength]

A release film-bearing PSA sheet (PSA layer) is cut 100 mm long and 20 mm wide. Subsequently, one release film is removed from the release film-bearing PSA sheet (PSA layer) and the PSA sheet is backed with PET film (product name LUMIRROR S-10 available from Toray Industries, Inc.; 25 μm thick). The other release film (on the measured side) is then removed and the PSA sheet is press-bonded to a glass plate

(product name Soda Lime Glass #0050 available from Matsunami Glass Ind., Ltd.) as a test panel by rolling a 2 kg roller back and forth once to prepare a test piece formed of the test panel/PSA sheet (PSA layer)/PET film. The resulting test piece is autoclaved (50 °C, 0.5 MPa, 15 minutes) and then allowed to cool for 30 minutes under atmosphere at 23 °C and 50 %RH. After cooled, using a tensile tester (model name AUTOGRAPH AG-IS available from Shimadzu Corporation), based on JIS Z 0237, at a tensile speed of 300 mm/min, at a peel angle of 180°, the peel strength is determined while the PSA sheet (PSA layer) (on the measured side) is peeled from the test panel. This is used as the to-glass adhesive strength (N/20mm).

In case of a PSA sheet protected with a double-release-faced release film, when the PSA sheet is unwound from the roll, one adhesive face is exposed and thus, this face can be backed with PET film for the measurement.

[0197]

[Arithmetic mean roughness (Ra) and maximum height (Rz)]

With respect to a PSA sheet's (PSA layer's) adhesive face, the arithmetic mean roughness (Ra) and maximum height (Rz) are determined as follows: The release film is removed from the release film-bearing PSA sheet (PSA layer) at a peel angle of 180° at a speed of 300 mm/min and the PSA sheet is then left still for 30 minutes. With respect to the exposed adhesive face, in an environment at 23 °C and 50 %RH, the surface structure is analyzed using a 3D optical profiler (product name NewView 7300 available from ZYGO Corporation).

From the data of measurement, the arithmetic mean roughness Ra is determined based on JIS B 0601-2001. With respect to the data (roughness curve) obtained by the measurement, the maximum height (Rz) is determined as the sum of the height Rp of the highest peak above the line of mean of the roughness curve and the depth Rv of the deepest valley below the mean line. The measurement conditions are as shown below. The Ra and Rz measurements are repeated five times (i.e. N = 5) each and the average values are used.

(Measurement conditions)

Measured area: 5.62 mm × 4.22 mm

(Objective lens: 2.5× magnification; Internal lens: 0.5× magnification)

Analytical mode:

Remove: Cylinder

Data Fill: ON (Max: 25)

Remove Spikes: ON (xRMS: 1)

Filter: OFF

[0198]

[Evaluation of optical distortion]

A 2 mm thick commercial mirror made from a plain glass panel by a silvering method is obtained and used after the absence of distortion is confirmed by visual inspection and by the reflected image of the mirror alone projected on screen by the same method described below. In a clean room, the sort of foreign matter is removed from the mirror surface with clean cloth. One release film of a release film-bearing PSA sheet (PSA layer) is then removed therefrom. The PSA sheet is adhered to the mirror surface with proper tension applied to prevent trapping of foreign particles, bubbles and deformative veins. In an autoclave, the resultant is subjected to degasification (conditions: 50 °C, 0.5 MPa, 15 min) to eliminate the influence of micro bubbles. After allowed to cool at room temperature for at least 30 minutes, the other release film is removed from the PSA sheet (PSA layer) to prepare an optical distortion test piece (a laminate formed of the PSA sheet (PSA layer) and mirror). The test sample is placed with the PSA sheet (PSA layer) side facing a point light source at an angle of approximately 45° relative to the light beam from the point light source. A white-color screen is arranged at a distance in the light beam direction (at a distance opposite the light source) to project the reflected image. As the point light source, product name Xenon Lamp C2577 available from Hamamatsu Photonics K.K. or a comparable product can be used. The point light source, test sample and screen are placed so that they are about 50 cm apart (50 cm in distance between the test sample and point light source as well as in distance between the test sample and screen).

The point light source is turned on and the image projected through the sample on the screen is visually inspected to evaluate the presence and degree of optical distortion based on the three grades described below.

E: No optical distortion observed

A: Some optical distortion observed, but an acceptable level for practical use

P: Obvious optical distortion observed

[0199]

[Elastic modulus by tensile test]

A release film-bearing PSA sheet (PSA layer) is cut 10 mm wide and 150 mm long to obtain a test piece. In an environment at 23 °C and 50 %RH, two release films are removed to expose the PSA layer. Using a tensile tester (model name AUTOGRAPH AG-IS available from Shimadzu Corporation), at a chuck distance of 120 mm, at a tensile speed of 50 mm/min, a tensile test is carried out on the test piece to obtain an S-S curve. The elastic modulus (MPa) is determined from the initial slope (in the viscoelastic deformation range of the S-S curve, or more specifically, in the range where ϵ is in a range below about 5 %).

[0200]

The thickness of the test piece used for the tensile test may be comparable to or different from the thickness of the PSA sheet (PSA layer) as described above. For instance, when the PSA sheet (PSA layer) has a relatively small thickness, for purposes such as facilitating the handling, the tensile test can be carried out on a test piece prepared to a thickness of 5 μm or greater (e.g. about 5 μm to 200 μm) and the resulting data can be used as the PSA sheet's (PSA layer's) elastic modulus. For instance, with respect to a photocurable PSA sheet, the thickness of the test piece can be adjusted by suitably layering PSA layers before photocuring UV irradiation. Alternatively, the same PSA composition as the one used for forming the analyzed PSA layer can be used to prepare a test piece having a thickness suited for the tensile test, and the data obtained by performing the tensile test on the test piece can be used as the PSA layer's elastic modulus. The tensile test can be carried out, using a test piece having a thickness of about 10 μm to 50 μm (preferably about 15 μm to 25 μm).

[0201]

[Impact strength]

A pendulum-type shear impact tester for adhesive bonds based on JIS K 6855 is used to carry out a shear impact test. A measurement sample is obtained as follows: A release film-bearing PSA sheet (PSA layer) is cut to a 10 mm square piece. One release film is removed to expose the first adhesive face of the PSA sheet (PSA layer) and the first adhesive face is adhered to the center of a 25 mm square chemically-reinforced glass plate (1.7 mm thick; available from Corning Inc.). The other release film is removed to expose the second adhesive face of the PSA sheet (PSA layer) and the second adhesive face is adhered to the center of a 40 mm square stainless steel plate (SUS304BA plate) and press-bonded under a 5 N load for 10 seconds. The resultant is autoclaved (50 °C, 0.5

MPa, 15 min), irradiated with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm², and then allowed to age at 50 °C for 48 hours for use as a sample.

The measurement sample is fastened with the stainless steel plate down. In an environment at 23 °C and 50 %RH, the outer circumference of the glass plate is struck with a hammer at a hammer energy of 2.75 J at a hammer speed (impact speed) of 3.5 m/s and the energy (J) absorbed during this is measured to determine the impact strength (J/10mm²). The measurement is repeated three times and their arithmetic mean value is used.

In case of a PSA sheet protected with a double-release-faced release film, when the PSA sheet is unwound from the roll, one adhesive face is exposed and thus, the analysis can be run on a measurement sample obtained by adhering a chemically-reinforced glass plate to this face, removing the release film to expose the other adhesive face and adhering the exposed face to the stainless steel plate.

[0202]

The PSA sheet (PSA layer) disclosed herein includes an embodiment in which the PSA layer is allowed to photocure after adhered to an adherend. Thus, at least with respect to a photocurable PSA sheet (e.g. the PSA sheet of Example 4 having PSA C described later), measurement samples are used after irradiated with UV at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm² and aged at 50 °C for 48 hours when carrying out the aforementioned measurements (total light transmittance, haze value, to-glass adhesive strength, adhesive face's arithmetic mean roughness (Ra) and maximum height (Rz), optical distortion test, elastic modulus by tensile test). As for the to-glass adhesive strength, the measurement is taken after the photocurable PSA sheet (e.g. the PSA sheet of Example 4 having PSA C described later) is press-bonded to the test plate and irradiated with UV rays under the aforementioned conditions. When the release film is transparent, the UV irradiation is preferably carried out with the PSA sheet (typically a PSA layer) placed between transparent release films.

Desirably, the dose and cumulative dose are measured using an industrial UV checker (model UVR-T2, detector unit: UD-T36T2 available from Topcon Technohouse Corporation) after adjusting the actual distance between the light source and sample.

[0203]

<Example 1>

(Preparation of PSA composition)

Were mixed 57 parts of n-butyl acrylate (BA), 12 parts of cyclohexyl acrylate (CHA), 23 parts of 4-hydroxybutyl acrylate (4HBA) and 8 parts of hydroxyethyl acrylate (HEA) as monomers; and 0.075 part each of product names IRGACURE 651 and IRGACURE 184 (both available from BASF Corporation) as photopolymerization initiators. The monomer mixture is then exposed to UV rays under nitrogen atmosphere and partial photopolymerization was carried out to obtain a partial polymer (acrylic polymer syrup) at an approximately 10 % monomer conversion. To 100 parts of the resulting acrylic polymer syrup, were added 0.14 part of pentaerythritol hexaacrylate (product name KAYARAD DPHA available from Nippon Kayaku Co., Ltd.) and 0.3 part of a silane coupling agent (product name KBM-403 available from Shin-Etsu Chemical Co., Ltd.) and evenly mixed to obtain an acrylic PSA composition A.

[0204]

(Preparation of PSA sheet)

As the first release film, was obtained a 75 μm thick PET release film having a silicone-based release face on the first adhesive face side surface S1 (R_a : 18 nm, R_z : 223 nm) to be layered on the PSA sheet's first adhesive face. As the second release film, was obtained a 100 μm thick PET release film having a silicone-based release face on the second adhesive face side surface S2 (R_a : 18 nm, R_z : 223 nm) to be layered on the PSA sheet's second adhesive face.

The acrylic PSA composition A obtained above is applied to the first adhesive face side surface S1 of the first release film to a final PSA layer thickness of 100 μm to form a PSA composition layer. Subsequently, the second release film was placed to cover the PSA composition layer surface with the second adhesive face side surface S2 on the PSA composition layer side, thereby blocking the PSA composition layer from oxygen. The PSA composition layer was subjected to UV irradiation at a dose of 5 mW/cm^2 to a cumulative dose of 2000 mJ/cm^2 and allowed to photocure to prepare a substrate-free double-faced PSA sheet consisting of an acrylic PSA layer (or PSAA) whose two faces are protected with the first and second release films. The acrylic polymer as the base polymer of the PSA layer had a weight average molecular weight (M_w) of 200×10^4 .

[0205]

<Example 2>

As the first and second release films, were used a release film whose first adhesive face side surface S1 had R_a of 18 nm and R_z of 112 nm and release film whose

second adhesive face side surface S2 had Ra of 18 nm and Rz of 112 nm, respectively. The PSA layer's thickness was changed to 25 μm . Otherwise in the same manner as Example 1, was prepared a substrate-free double-faced PSA sheet according to this Example.

[0206]

<Example 3>

The monomers were changed to 68 parts of 2-ethylhexyl acrylate (2EHA), 15 parts of N-vinyl-pyrrolidone (NVP) and 17 parts of HEA, but otherwise in the same manner as Example 1, was prepared an acrylic polymer syrup. Using the resulting acrylic polymer syrup, but otherwise in the same manner as Example 1, was obtained an acrylic PSA composition B. Using the resulting acrylic PSA composition B and forming a PSA layer (or PSA B) 50 μm thick, but otherwise in the same manner as Example 2, was prepared a substrate-free double-faced PSA sheet.

[0207]

<Example 4>

(Preparation of PSA composition)

Into a reaction vessel equipped with a condenser, nitrogen inlet, thermometer and stirrer, were added 60 parts of BA, 6 parts of CHA, 18 parts of NVP, 1 part of isostearyl acrylate (iSTA) and 15 parts of 4HBA as monomers; and 0.085 part of α -thioglycerol as chain transfer agent, 0.2 part of 2,2'-azobisisobutyronitrile (AIBN) as thermal polymerization initiator and ethyl acetate as polymerization solvent to a 45 % monomer content. While stirring, the reaction vessel was purged with nitrogen for about 1 hour. Subsequently, the reaction vessel was heated to 60 °C and the reaction was carried out for 7 hours to obtain an acrylic polymer having a weight average molecular weight (M_w) of 35×10^4 . To the acrylic polymer solution (100 parts of non-volatiles (NV)), were added 0.1 part (by NV) of trimethylolpropane/xylylene diisocyanate adduct (product name TAKENATE D-110N available from Mitsui Chemicals, Inc.; 75 % NV) as isocyanate-based crosslinking agent, 0.01 part of dioctyltin dilaurate (product name EMBILIZER OL-1 available from Tokyo Fine Chemical Co., Ltd.) as crosslinking catalyst, 4 parts of acetylacetone as crosslinking retarder, 0.3 part of 3-glycidoxypropyltrimethoxysilane (product name KBM-403 available from Shin-Etsu Chemical Co., Ltd.) as silane coupling agent, 8 parts of dipentaerythritol hexaacrylate (product name A-DPH available from Shin-Nakamura Chemical Co., Ltd.) and 12 parts of tricyclodecane dimethanol diacrylate (product name A-DCP available from Shin-

Nakamura Chemical Co., Ltd.) as photoreactive monomers, and 0.7 part of 1-hydroxycyclohexyl phenyl ketone (product name OMNIRAD 184 available from IGM Regins B. V.) as photopolymerization initiator; and evenly mixed to prepare a PSA composition C according to this Example.

[0208]

(Preparation of PSA sheet)

As the first and second release films, were used release films with surfaces S1 and S2 having the Ra and Rz values shown in Table 1.

Onto the first adhesive face side surface S1 of the first release film, was applied the resulting PSA composition C to a thickness of 20 μm when dried. Under normal pressure, the resultant was allowed to dry at 60 °C for 1 minute and at 120 °C for 3 minutes, and further allowed to age at 23 °C for 120 hours to form a photocurable PSA layer (substrate-free double-faced PSA sheet). To the surface of the photocurable PSA layer, the second adhesive face side surface S2 of the second release film was adhered for protection. Accordingly, was prepared a substrate-free double-faced PSA sheet consisting of a photocurable acrylic PSA layer (or PSA C) whose two faces are protected with the first and second release films.

[0209]

<Example 5>

As the first and second release films, were used a release film whose first adhesive face side surface S1 had Ra of 18 nm and Rz of 112 nm and release film whose second adhesive face side surface S2 had Ra of 18 nm and Rz of 112 nm, respectively. The PSA layer's thickness was changed to 100 μm . Otherwise in the same manner as Example 3, was prepared a substrate-free double-faced PSA sheet according to this Example.

[0210]

<Preparation of laminate>

(Preparation of decorative film)

As a substrate film, was obtained a PET film (125 μm thick, 340 mm wide) available from Mitsubishi Plastics, Inc. By DC magnetron sputtering, along the substrate film surface, was directly formed a 5 nm thick ITO layer. When forming the ITO layer, the substrate film temperature was set at 130 °C. The ITO had a 10 % tin oxide (SnO_2) content ($= \text{SnO}_2 / (\text{In}_2\text{O}_3 + \text{SnO}_2) \times 100$). Subsequently, by AC sputtering (AC: 40 kHz), was

formed a 30 nm thick aluminum (Al) layer on the ITO layer. The resulting Al layer was non-continuous. When forming the Al layer, the substrate film temperature was set at 130 °C. On the Al layer, by RF (13.6 MHz) powered sputtering, was formed a 20 nm thick AlO_x barrier layer to obtain a metallic luster film (decorative film). When forming the barrier layer, the substrate film temperature was set at room temperature. The decorative film's Al layer and ITO-containing layer had a sheet resistance of 3000 Ω/sq or greater and a visible light transmittance of 7 % or lower.

[0211]

(Preparation of laminate)

From the release film-bearing PSA sheet (PSA layer) according to each Example, was removed the first release film to expose the first adhesive face. To the exposed adhesive face, was press-bonded a glass slide (product name White, Polished No. 1 available from Matsunami Glass Ind., Ltd.; 0.8-1.0 mm thick, 92 % total light transmittance, 0.2 % haze) as a transparent member by rolling a 2 kg roller back and forth once. Subsequently, from the PSA sheet (PSA layer), was removed the second release film to expose the second adhesive face. To the exposed adhesive face, was press-bonded the decorative film obtained above to prepare a laminate in which the transparent, PSA layer and decorative film in this order. The laminate had a visible light transmittance of 7 % or lower.

[0212]

<Evaluations>

The release film-bearing PSA sheets (PSA layers) according to the respective Examples were tested for total light transmittance (%), haze value (%), to-glass adhesive strength (N/20mm), adhesive face's arithmetic mean roughness Ra (nm), maximum height Rz (nm) and optical distortion. The results are shown in Table 1. With respect to the PSA sheet of Example 4, the elastic modulus was determined by the tensile test. The PSA sheets of Examples 1 to 4 were tested for impact strength. Table 1 also summarizes the features (PSA species, PSA sheet's (PSA layer's) thickness (μm), 25°C storage modulus (Pa) and gel fraction (%)) of the respective Examples.

[0213]

[Table 1]

Table 1

		Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5
PSA sheet (PSA layer)	PSA	A	A	B	C	B
	Thickness (μm)	100	25	50	20	100
	25°C storage modulus (Pa)	1.2×10^5	1.2×10^5	2.0×10^5	0.8×10^5	2.0×10^5
	Gel fraction (%)	84	86	88	57	89
	Total light transmittance (%)	92.3	92.4	92.3	92.4	92.3
	Haze value (%)	0.47	0.22	0.32	0.22	0.34
	To-glass adhesive strength (N/20mm)	12	8	11	10	15
	1st adhesive face Ra (nm)	50	37	62	42	68
	Rz (nm)	333	262	341	235	355
	2nd adhesive face Ra (nm)	60	48	53	43	65
	Rz (nm)	383	311	387	282	392
Optical distortion		E	E	E	E	A

[0214]

As shown in Table 1, in any of the PSA layers of Examples 1 to 5, optical distortion was not observed or was in a practically-acceptable range. These results show that according to a laminate having the PSA sheet (PSA layer) between a transparent member and decorative film, the design on the decorative film surface can be well observed through the transparent member and PSA layer. It is noted that the PSA sheet (PSA layer) according to Example 4 had an elastic modulus of 3.0 MPa or greater by the tensile test; and the PSA sheets (PSA layers) of Examples 1 to 4 all had impact strengths of 2.0 J/10mm² or greater.

[0215]

Although specific embodiments of the present invention have been described in detail above, these are merely for illustrations and do not limit the scope of the claims. The art according to the claims includes various modifications and changes made to the specific embodiments illustrated above.

WHAT IS CLAIMED IS:

1. A laminate having a transparent member, a pressure-sensitive adhesive layer and a decorative film placed in this order.
2. The laminate according to Claim 1, having a visible light transmittance below 10 % in the layering direction of the transparent member, the pressure-sensitive adhesive layer and the decorative film.
3. The laminate according to Claim 1 or 2, wherein the pressure-sensitive adhesive layer surface has an arithmetic mean roughness Ra of 70 nm or less and a maximum height Rz of 600 nm or less.
4. The laminate according to any one of Claims 1 to 3, wherein the pressure-sensitive adhesive layer has a total light transmittance of 85 % or higher and a haze value of 1 % or lower in its layering direction.
5. The laminate according to any one of Claims 1 to 4, wherein the pressure-sensitive adhesive layer has a storage modulus of 4×10^4 Pa or greater at 25 °C.
6. The laminate according to any one of Claims 1 to 5, wherein the pressure-sensitive adhesive layer is bonded to the transparent member with a 180° peel strength greater than 7 N/20mm.
7. The laminate according to any one of Claims 1 to 6, wherein the pressure-sensitive adhesive layer is an acrylic pressure-sensitive adhesive layer.
8. The laminate according to any one of Claims 1 to 7, wherein the pressure-sensitive adhesive layer has an elastic modulus of 3.0 MPa or greater, determined by the following tensile test:

[tensile test]

the pressure-sensitive adhesive layer is irradiated with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm² and allowed to age at 50 °C for 48 hours;

the pressure-sensitive adhesive layer is then cut to a 10 mm wide, 150 mm long size to prepare a test piece; in an environment at 23 °C and 50 %RH, using a tensile tester, a tensile test is carried out on the test piece at a chuck distance of 120 mm at a tensile speed of 50 mm/min to obtain a stress-displacement curve; and from the initial slope, the elastic modulus (MPa) is determined.

9. The laminate according to any one of Claims 1 to 8, wherein the pressure-sensitive adhesive layer has an impact strength of 2.0 J/10mm² or greater, determined by the following shear impact test:

[shear impact test]

using a pendulum-type shear impact tester for adhesive bonds based on JIS K 6855, the shear impact test is carried out on a measurement sample obtained by applying the first face of a 10 mm square piece of the pressure-sensitive adhesive layer to the center of a 25 mm square chemically-reinforced glass plate (1.7 mm thick) and then applying the second face thereof to the center of a 40 mm square stainless steel plate (SUS304BA plate); press-bonding them under a 5 N load for 10 seconds; autoclaving the resultant (50 °C, 0.5 MPa, 15 min); irradiating it with UV rays at a dose of 300 mW/cm² to a cumulative dose of 3000 mJ/cm²; and then allowing it to age at 50 °C for 48 hours;

the measurement sample is fastened with the stainless steel plate down; in an environment at 23 °C and 50 %RH, the outer circumference of the glass plate is struck with a hammer at a hammer energy of 2.75 J at a hammer speed of 3.5 m/s; and the energy (J) absorbed during this is measured to determine the impact strength (J/10mm²).

10. The laminate according to any one of Claims 1 to 9, wherein the pressure-sensitive adhesive layer comprises a polymer (A) and a photoreactive monomer (B).

11. The laminate according to Claim 10, wherein the photoreactive monomer (B) comprises a compound B1 having a ring structure and two or more ethylenically unsaturated groups per molecule, and the compound B1 has a molecular weight of 100 g/mol per ethylenically unsaturated group.

12. The laminate according to any one of Claims 1 to 11, wherein the decorative film has a substrate layer and a decoration layer covering at least part of at least one face of

the substrate layer, with the decoration layer having a thickness in the range between 1 nm and 1000 nm.

13. The laminate according to Claim 12, wherein the decoration layer has a sheet resistance of 100 Ω/sq or greater.

14. The laminate according to any one of Claims 1 to 13, wherein the transparent member has a rectilinear bend or a curvilinear arc in an arbitrary cross section in parallel with the layering direction of the laminate, and the pressure-sensitive adhesive layer and the decorative film are placed where the bend or the arc of the transparent member exists.

15. The laminate according to any one of Claims 1 to 14, further having one, two or more colored layers, wherein each of the colored layers is placed at any location among the following: between the transparent member and the pressure-sensitive adhesive layer, between the pressure-sensitive adhesive layer and the decorative film, and on the reverse side of the pressure-sensitive adhesive layer side of the decorative film.

16. The laminate according to any one of Claims 1 to 15, used in a portable electronic device.