

## DESCRIPTION

TITLE OF THE INVENTION: ULTRAVIOLET-CURABLE ACRYL-BASED  
PRESSURE-SENSITIVE ADHESIVE COMPOSITION, ULTRAVIOLET-  
CURABLE ACRYL-BASED PRESSURE-SENSITIVE ADHESIVE LAYER,  
PRESSURE-SENSITIVE ADHESIVE LAYER-ATTACHED POLARIZING FILM,  
METHOD FOR PRODUCING ULTRAVIOLET-CURABLE ACRYL-BASED  
PRESSURE-SENSITIVE ADHESIVE LAYER AND IMAGE DISPLAY DEVICE

## TECHNICAL FIELD

[0001]

The present invention relates to an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition for forming a pressure-sensitive-adhesive layer positioned between a cover glass or cover plastic, and a polarizing film in an image display device. The invention also relates to an ultraviolet-curable acryl-based pressure-sensitive-adhesive layer made from the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition, a pressure-sensitive-adhesive layer-attached polarizing film having the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer, a method for producing the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer, and an image display device. Examples of the image display device include a liquid crystal display device, an organic EL (electroluminescence) display device, a PDP

(plasma display panel), and an electronic paper piece.

#### BACKGROUND ART

[0002]

Liquid crystal display devices, organic EL display devices, etc. have an image-forming mechanism including polarizing elements as essential components. For example, therefore, in a liquid crystal display device, polarizing elements are essentially arranged on both sides of a liquid crystal cell, and generally, polarizing films are attached as the polarizing elements. Besides polarizing films, various optical elements for improving display quality have become used in display panels such as liquid crystal panels and organic EL panels.

[0003]

A polarizing film used in such image display devices generally has a structure in which a polarizer is sandwiched between two protective films. As the protective films, triacetylcellulose (TAC) has been widely used.

[0004]

With a current such that image display devices are made lighter and thinner in recent years, individual members used in the image display devices are required to be made thinner, and a protective film for their polarizing film is also required to be made thinner. When the

thickness of the protective film is made small, this film becomes incapable of making a sufficient cut of ultraviolet rays radiated into the image display devices.

Consequently, there is caused a problem of accelerating an ultraviolet-induced deterioration of not only their polarizer but also other various optical members used in the image display devices, examples of these members including a liquid crystal panel and an organic electroluminescent element.

[0005]

In order to solve such a problem, for example, the following are known: a transparent double-sided pressure-sensitive adhesive sheet, for image display device, which is located between a surface protective panel in an image display device, and a viewing side of a liquid crystal module therein in order to integrate these two members with each other, this pressure-sensitive adhesive sheet having at least one ultraviolet absorbing layer, and having a light ray transmittance of 30% or less at a wavelength of 380 nm and a visible ray transmittance of 80% or more in wavelengths longer than a wavelength of 430 nm (see, for example, Patent Document 1); and a pressure-sensitive adhesive sheet having a pressure-sensitive-adhesive layer including an acryl-based polymer and a triazine type ultraviolet absorbent (see, for example, Patent Document

2). Furthermore, about a pressure-sensitive-adhesive optical film in which a pressure-sensitive-adhesive layer is laid onto one surface or each surface of an optical film, it is known that an ultraviolet absorbing function can be given to the pressure-sensitive-adhesive layer (see, for example, Patent Document 3).

#### PRIOR ART DOCUMENTS

##### PATENT DOCUMENTS

[0006]

Patent Document 1: JP-A-2012-211305

Patent Document 2: JP-A-2013-75978

Patent Document 3: Japanese Patent No. 4208187

#### SUMMARY OF THE INVENTION

##### PROBLEMS TO BE SOLVED BY THE INVENTION

[0007]

The respective pressure-sensitive adhesive sheets in Patent Documents 1 and 2 described above do not sufficiently have any ultraviolet absorbing function since their pressure-sensitive-adhesive layer containing an ultraviolet absorbent is small in thickness. Moreover, the thickness of the pressure-sensitive-adhesive layer is small, so that problems may be caused, examples thereof including an inconvenience that air bubbles are generated

when this layer requires an irregularity (level difference)-absorbing performance. According to these Patent Documents, in the formation of the ultraviolet-absorbent-containing pressure-sensitive-adhesive layer, polymerization using ultraviolet radiation is not performed. Thus, naturally, no investigations have been made about any photopolymerization initiator having an absorption band at wavelengths of 400 nm or more.

[0008]

Furthermore, Patent Document 3 never makes a specific investigation about the formation of a pressure-sensitive-adhesive layer having ultraviolet absorbing function, using a polymerization method based on ultraviolet radiation. A sufficient investigation is not made, either, about a photopolymerization initiator having an absorption band at wavelengths of 400 nm or more.

[0009]

Additionally, according to documents other than Patent Documents 1 to 3, various transparent pressure-sensitive adhesives are known which each have ultraviolet absorbing function. However, most of transparent pressure-sensitive adhesives which each have ultraviolet absorbing function and are known at present are each a pressure-sensitive adhesive containing a base polymer produced by solution polymerization. Such a producing method has

difficulties in producing a thick product having a thickness of 150  $\mu\text{m}$  or more to impose a restriction to the thickness of a pressure-sensitive-adhesive layer that can be produced. In the case of using the polymerization method based on ultraviolet radiation, it is known that a thick pressure-sensitive-adhesive layer can be produced. However, in the present circumstances, no method has been known in which a pressure-sensitive-adhesive layer having ultraviolet absorbing function is produced by polymerization based on ultraviolet radiation.

[0010]

Thus, an object of the present invention is to provide an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition in which a pressure-sensitive-adhesive layer having ultraviolet absorbing function can be formed by polymerization based on ultraviolet radiation. Another object of the invention is to provide an ultraviolet-curable acryl-based pressure-sensitive-adhesive layer formed from this ultraviolet-curable acryl-based pressure-sensitive-adhesive composition; a pressure-sensitive-adhesive layer-attached polarizing film having this ultraviolet-curable acryl-based pressure-sensitive-adhesive layer; a method for producing the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer; and an image display device.

## MEANS FOR SOLVING THE PROBLEMS

[0011]

As a result of intensive studies to solve the problems, the inventors have accomplished the invention by finding the ultraviolet-curable acryl-based pressure-sensitive adhesive composition described below.

[0012]

That is, the invention relates to an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition for forming a pressure-sensitive-adhesive layer positioned between a cover glass or cover plastic and a polarizing film in an image display device,

the pressure-sensitive-adhesive composition comprising a monomer component comprising an alkyl (meth)acrylate and/or a partially polymerized product made from the monomer component, an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more, and

a pressure-sensitive-adhesive layer formed from the pressure-sensitive-adhesive composition having a transmittance of 40% or less at a wavelength of 380 nm, and having a transmittance of 30% or more at a wavelength of 400 nm.

[0013]

In the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the present invention, the pressure-sensitive-adhesive layer preferably has a transmission  $b^*$  value of 3.0 or less.

[0014]

In the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the present invention, the ultraviolet absorbent is preferably at least one ultraviolet absorbent selected from the group consisting of a triazine-based ultraviolet absorbent having, in one molecule, two or less hydroxyl groups, and a benzotriazole-based ultraviolet absorbent having, in one molecule, one benzotriazole skeleton.

[0015]

In the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the present invention, the photopolymerization initiator (A) is preferably smaller in addition amount than the ultraviolet absorbent.

[0016]

The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the present invention preferably further comprises a photopolymerization initiator (B) having an absorption band at wavelengths less than 400 nm.

[0017]

The present invention relates to an ultraviolet-curable acryl-based pressure-sensitive-adhesive layer, which is a pressure-sensitive-adhesive layer positioned between a cover glass or cover plastic, and a polarizing film in an image display device, and

which is formed by radiating an ultraviolet ray to the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition to photopolymerize the monomer component in the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition.

[0018]

The present invention relates to a pressure-sensitive-adhesive layer-attached polarizing film, comprising a polarizing film, and the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer positioned on/over at least one surface of the polarizing film.

[0019]

The present invention also relates to a method for producing an ultraviolet-curable acryl-based pressure-sensitive adhesive layer formed from the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition comprising a photopolymerization initiator (B), the method comprising:

the step of radiating a composition comprising a monomer component comprising an alkyl (meth)acrylate, and

the photopolymerization initiator (B) to produce a partially polymerized product made from the monomer component;

the step of adding an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more to the partially polymerized product made from the monomer component to produce an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition; and

the step of applying the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition to at least one surface of a substrate, and radiating an ultraviolet ray to the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition.

[0020]

The present invention further relates to an image display device, having at least a cover glass or cover plastic, and a polarizing film,

the display device having the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer positioned between the cover glass or cover plastic and the polarizing film.

EFFECT OF THE INVENTION

[0021]

The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the present invention allows to form a pressure-sensitive-adhesive layer having ultraviolet absorbing function by polymerization based on ultraviolet radiation. Thus, a pressure-sensitive-adhesive layer having a large thickness of 150  $\mu\text{m}$  or more can be formed. Consequently, pressure-sensitive-adhesive layers can be formed which each having a thickness in a wide range. The pressure-sensitive-adhesive layer of the invention has an excellent ultraviolet absorbing function; thus, the use of this pressure-sensitive-adhesive layer in an image display device allows to restrain a deterioration of its optical members, typical examples thereof including a liquid crystal panel, an organic EL element, and a polarizer.

#### BRIEF DESCRIPTION OF THE DRAWINGS

[0022]

Fig. 1 is a sectional view which schematically illustrates an embodiment of the image display device of the invention.

Fig. 2 is a sectional view which schematically illustrates an embodiment of the image display device of the invention.

Fig. 3 is a sectional view which schematically

illustrates an embodiment of the image display device of the invention.

#### MODE FOR CARRYING OUT THE INVENTION

[0023]

##### 1. Ultraviolet-Curable Acryl-Based Pressure-Sensitive-Adhesive Composition

The acryl-based pressure-sensitive-adhesive composition of the present invention is an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition for forming a pressure-sensitive-adhesive layer positioned between a cover glass or cover plastic and a polarizing film in an image display device;

this pressure-sensitive-adhesive composition including a monomer component including an alkyl (meth)acrylate and/or a partially polymerized product made from the monomer component, an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more; and

a pressure-sensitive-adhesive layer formed from the pressure-sensitive-adhesive composition having a transmittance of 40% or less at a wavelength of 380 nm, and having a transmittance of 30% or more at a wavelength of 400 nm.

[0024]

A detailed description will be made about embodiments of an image display device including the pressure-sensitive-adhesive layer of the present invention with reference to the drawings. However, the invention is not limited to the embodiments in the drawings.

[0025]

As illustrated in Figs. 1 to 3, an example of the structure of the image display device is an image display device having the following:

a cover glass or cover plastic 1/a pressure-sensitive-adhesive layer 2a/a polarizing film 5/a liquid crystal display device (LCD) or an organic EL display device (OLED) 6;

a cover glass or cover plastic 1/a pressure-sensitive-adhesive layer 2b/a sensor layer 7/a pressure-sensitive-adhesive layer 2a/a polarizing film 5/a liquid crystal display device (LCD) or an organic EL display device (OLED) 6; or

a cover glass or cover plastic 1/a pressure-sensitive-adhesive layer 2b/a sensor layer 7/a pressure-sensitive-adhesive layer 2c/a sensor layer 7/a pressure-sensitive-adhesive layer 2a/a polarizing film 5/a liquid crystal display device (LCD) or an organic EL display device (OLED) 6;

these layers being laminated onto each other in this

order. Besides these layers, for example, a retardation film may be appropriately added to the image display device. Specifically, the retardation film may be laminated into between the polarizing film 5 and the liquid crystal display device (LCD) or organic EL display device (OLED) 6 to interpose a pressure-sensitive-adhesive layer therebetween. For the lamination of any two of the individual layers onto each other, a pressure-sensitive-adhesive layer and/or an adhesive layer may be appropriately used. The polarizing film 5 in each of Figs. 1 to 3 has a structure in which a polarizer 4 is sandwiched between two protective films 3a and 3b. However, the polarizing film may be a single-sided protected polarizing film in which a single surface of the polarizer 4 is protected by a protective film.

[0026]

A pressure-sensitive-adhesive layer made from the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the present invention is a pressure-sensitive-adhesive layer positioned between the cover glass or cover plastic 1 in the image display device, and the polarizing film 5 that is present nearer to the viewing side than the liquid crystal display device (LCD) or organic EL display device (OLED) 6. The pressure-sensitive-adhesive layer may be a layer at the site of any

one of the respective pressure-sensitive-adhesive layers 2a to 2c in Figs. 1 to 3. It is more preferred from the viewpoint of the ultraviolet absorbing function of the pressure-sensitive adhesive layer to use the pressure-sensitive-adhesive layer of the present invention as the pressure-sensitive-adhesive layer contacting the polarizing film 5 (the layer 2a in each of the figures). When the pressure-sensitive-adhesive layer made from the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the present invention at the above-mentioned position, the polarizing film and others in the image display device can be favorably protected from ultraviolet rays radiated from the viewing side of the image display device into this display device.

[0027]

The ultraviolet-curable acryl-based pressure-sensitive adhesive composition of the invention includes a monomer component including an alkyl (meth)acrylate and a partially polymerized product of the monomer component(s), an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorbing band in wavelengths of 400 nm or more.

[0028]

The alkyl (meth)acrylate is, for example, an alkyl (meth)acrylate having a linear or branched alkyl group of 1

to 24 carbon atoms at an ester end. Such alkyl (meth)acrylates may be used singly or in any combination of two or more thereof. The wording alkyl (meth)acrylate denotes an alkyl acrylate and/or an alkyl methacrylate. The word "(meth)" in the present invention has substantially the same meaning.

[0029]

Examples of the alkyl (meth)acrylate includes an alkyl (meth)acrylate having a branched alkyl group of 4 to 9 carbon atoms at an ester end. These alkyl (meth)acrylates are each favorable since the resultant pressure-sensitive-adhesive layer easily takes a balance between its adhesive properties. Specific examples of the alkyl (meth)acrylate include n-butyl (meth)acrylate, s-butyl (meth)acrylate, t-butyl (meth)acrylate, isobutyl (meth)acrylate, n-pentyl (meth)acrylate, isopentyl (meth)acrylate, isohexyl (meth)acrylate, isoheptyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, isooctyl (meth)acrylate, and isononyl (meth)acrylate. These may be used singly or in any combination of two or more.

[0030]

In the present invention, the proportion of the above-mentioned alkyl (meth)acrylate having an alkyl group of 1 to 24 carbon atoms at an ester end, is preferably 40% or more by weight, more preferably 50% or more by weight,

even more preferably 60% or more by weight of the whole of one or more monofunctional monomer component(s) from which the (meth)acryl-based polymer is made.

[0031]

The above-mentioned monomer component(s) for forming the (meth)acryl-based polymer may include, as one of the monofunctional monomer component(s), a copolymerizable monomer other than the alkyl (meth)acrylate. The copolymerizable monomer is usable as the rest of the monomer component(s) that is other than the alkyl (meth)acrylate.

[0032]

As the copolymerizable monomer, the monomer component(s) may include, for example, a cyclic nitrogen-containing monomer. It is allowable to use, as the cyclic nitrogen-containing monomer, a monomer having a polymerizable functional group having an unsaturated double bond, such as a (meth)acryloyl group or vinyl group, and further having a cyclic nitrogen structure without any especial limitation. The cyclic nitrogen structure is preferably a cyclic structure having therein one or more nitrogen atoms. Examples of the cyclic nitrogen-containing monomer include lactam-based vinyl monomers such as N-vinylpyrrolidone, N-vinyl- $\epsilon$ -caprolactam, and methylvinylpyrrolidone; vinyl monomers each having a

nitrogen-containing heterocyclic ring such as vinylpyridine, vinylpiperidone, vinylpyrimidine, vinylpiperazine, vinylpyrazine, vinylpyrrole, vinylimidazole, vinyloxazole, and vinylmorpholine. Other examples thereof include (meth)acrylic monomers each containing a heterocyclic ring such as a morpholine ring, a piperidine ring, a pyrrolidine ring, or a piperazine ring. Specific examples thereof include N-acryloylmorpholine, N-acryloylpiperidine, N-methacryloylpiperidine, and N-acryloylpyrrolidine. Among these cyclic nitrogen-containing monomers, lactam-based vinyl monomers are preferred.

[0033]

In the present invention, the proportion of the cyclic nitrogen-containing monomer is preferably from 0.5 to 50% by weight, more preferably from 0.5 to 40% by weight, even more preferably from 0.5 to 30% by weight of the whole of the monofunctional monomer component(s) from which the (meth)acryl-based polymer is made.

[0034]

The monomer component(s) used in the present invention may include, as one of the monofunctional monomer component(s), a hydroxyl-group-containing monomer. It is allowable to use, as the hydroxyl-group-containing monomer, a monomer having a polymerizable functional group having an

unsaturated double bond, such as a (meth)acryloyl group or vinyl group, and further having a hydroxyl group with especial limitation. Examples of the hydroxyl-group-containing monomer include hydroxylalkyl (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, and 12-hydroxylauryl (meth)acrylate; and hydroxyalkylcycloalkane (meth)acrylates such as (4-hydroxymethylcyclohexyl)methyl (meth)acrylate. Other examples thereof include hydroxyethyl (meth)acrylamide, allyl alcohol, 2-hydroxyethyl vinyl ether, 4-hydroxybutyl vinyl ether, and diethylene glycol monovinyl ether. These monomers may be used singly or in combination. Thereamong, hydroxyalkyl (meth)acrylates are preferred.

[0035]

In the present invention, since the pressure-sensitive-adhesive composition is heightened in adhering strength and cohesive strength, the proportion of the hydroxyl-group-containing monomer is preferably 1% or more by weight, more preferably 2% or more by weight, even more preferably 3% or more by weight of the whole of the monofunctional monomer component(s), from which the

(meth)acryl-based polymer is made. However, if the proportion of the hydroxyl-group-containing monomer is too large, the pressure-sensitive-adhesive layer may be hardened to be lowered in adhering strength. Moreover, the pressure-sensitive adhesive may become too high in viscosity or may be gelatinized. Thus, the proportion of the hydroxyl-group-containing monomer is preferably 30% or less by weight, more preferably 27% or less by weight, even more preferably 25% or less by weight of the whole of the monofunctional monomer component(s), from which the (meth)acryl-based polymer is made.

[0036]

The monomer component(s), from which the (meth)acryl-based polymer is made, may contain, as one of the monofunctional monomers, any other functional-group-containing monomer. The other functional-group-containing monomer is, for example, a carboxyl-group-containing monomer or a monomer having a cyclic ether group.

[0037]

It is allowable to use, as the carboxyl-group-containing monomer, a monomer having a polymerizable functional group having an unsaturated double bond, such as a (meth)acryloyl group or vinyl group, and further having a carboxyl group without any especial limitation. Examples of the carboxyl-group-containing monomer include

(meth)acrylic acid, carboxyethyl (meth)acrylate, carboxypentyl (meth)acrylate, itaconic acid, maleic acid, fumaric acid, crotonic acid, and isocrotonic acid. These monomers are usable singly or in combination. Itaconic acid and maleic acid are each usable in the form of an anhydride thereof. Thereamong, acrylic acid and methacrylic acid are preferred, and acrylic acid is particularly preferred. For the monomer component(s) used in the production of the (meth)acryl-based polymer in the present invention, the carboxyl-group-containing monomer is arbitrarily usable. However, the carboxyl-group-containing monomer may not be used.

[0038]

It is allowable to use, as the monomer having a cyclic ether group, a monomer having a polymerizable functional group having an unsaturated double bond, such as a (meth)acryloyl group or vinyl group, and further having a cyclic ether group such as an epoxy group or oxetane group without any especial limitation. Examples of the epoxy-group-containing monomer include glycidyl (meth)acrylate, 3,4-epoxycyclohexylmethyl (meth)acrylate, and 4-hydroxybutyl (meth)acrylate glycidyl ether. Examples of the oxetane-group-containing monomer include 3-oxetanylmethyl (meth)acrylate, 3-methyl-3-oxetanylmethyl (meth)acrylate, 3-ethyl-3-oxetanylmethyl (meth)acrylate, 3-

butyl-3-oxetanylmethyl (meth)acrylate, and 3-hexyl-3-oxetanylmethyl (meth)acrylate. These monomers may be used singly or in combination.

[0039]

In the present invention, the proportion of the carboxyl-group-containing monomer or the monomer having a cyclic ether group is preferably 30% or less by weight, more preferably 27% or less by weight, even more preferably 25% or less by weight of the whole of the monofunctional monomer component(s), from which the (meth)acryl-based polymer is made.

[0040]

With respect to the monomer component(s) from which the (meth)acryl-based polymer is made, the copolymerizable monomer is, for example, an alkyl (meth)acrylate represented by  $\text{CH}_2=\text{C}(\text{R}^1)\text{COOR}^2$  wherein  $\text{R}^1$  represents hydrogen or a methyl group, and  $\text{R}^2$  represents a substituted alkyl group of 1 to 3 carbon atoms, or a cyclic alkyl group.

[0041]

About the substituted alkyl group of 1 to 3 carbon atoms as  $\text{R}^2$ , its substituent is preferably an aryl group of 3 to 8 carbon atoms or an aryloxy group of 3 to 8 carbon atoms. The aryl group is not limited, and is preferably a phenyl group.

[0042]

Examples of the monomer represented by  $\text{CH}_2=\text{C}(\text{R}^1)\text{COOR}^2$  include phenoxyethyl (meth)acrylate, benzyl (meth)acrylate, cyclohexyl (meth)acrylate, 3,3,5-trimethylcyclohexyl (meth)acrylate, and isobornyl (meth)acrylate. These monomers may be used singly or in combination.

[0043]

In the present invention, the proportion of the (meth)acrylate represented by  $\text{CH}_2=\text{C}(\text{R}^1)\text{COOR}^2$  may be 50% or less by weight of the whole of the monofunctional monomer component(s), from which the (meth)acryl-based polymer is made, and is preferably 45% or less by weight, more preferably 40% or less by weight, even more preferably 35% or less by weight thereof.

[0044]

The following may also be used as other copolymerizable monomer: vinyl acetate, vinyl propionate, styrene,  $\alpha$ -methyl styrene; glycol acrylate-based monomers such as polyethylene glycol (meth)acrylate, polypropylene glycol (meth) acrylate, methoxy ethylene glycol (meth)acrylate, and methoxy polypropylene glycol (meth)acrylate; acrylate-based monomers such as tetrahydrofurfuryl (meth)acrylate, fluorine (meth)acrylate, silicone (meth)acrylate, and 2-methoxyethyl acrylate; and amide-group-containing monomers, amino-group-containing monomers, imide-group-containing monomers, N-

acryloylmorpholine, and vinyl ether monomers. Furthermore, the following may also be used as the copolymerizable monomer: terpene (meth)acrylate, dicyclopentanyl (meth)acrylate, or any other monomer having a cyclic structure.

[0045]

Furthermore, the copolymerizable monomer may be, for example, a silicon-atom-containing silane-based monomer. Examples of the silane-based monomer include 3-acryloxypropyltriethoxysilane, vinyltrimethoxysilane, vinyltriethoxysilane, 4-vinylbutyltrimethoxysilane, 4-vinylbutyltriethoxysilane, 8-vinyl-octyltrimethoxysilane, 8-vinyloctyltriethoxysilane, 10-methacryloyloxydecyltrimethoxysilane, 10-acryloyloxydecyltrimethoxysilane, 10-methacryloyloxydecyltriethoxysilane, and 10-acryloyloxydecyltriethoxysilane.

[0046]

The monomer component(s), from which the (meth)acryl-based polymer is made, may optionally include a polyfunctional monomer beside the above-exemplified monofunctional monomers, so as to adjust the cohesive strength of the pressure-sensitive adhesive.

[0047]

The polyfunctional monomer is a monomer having at

least two polymerizable functional groups each having an unsaturated double bond such as a (meth)acryloyl group or vinyl group. Examples thereof include ester compounds of a polyhydric alcohol with (meth)acrylic acid such as (poly)ethylene glycol di(meth)acrylate, (poly)propylene glycol di(meth)acrylate, neopentyl glycol di(meth)acrylate, pentaerythritol di(meth)acrylate, pentaerythritol tri(meth)acrylate, dipentaerythritol hexa(meth)acrylate, 1,2-ethylene glycol di(meth)acrylate, 1,6-hexanediol di(meth)acrylate, 1,12-dodecanediol di(meth)acrylate, trimethylolpropane tri(meth)acrylate, and tetramethylolmethane tri(meth)acrylate; and allyl (meth)acrylate, vinyl (meth)acrylate, divinylbenzene, epoxy acrylate, polyester acrylate, urethane acrylate, butyl di(meth)acrylate, and hexyl di(meth)acrylate. Thereamong, the following is preferably usable: trimethylolpropane tri(meth)acrylate, hexanediol di(meth)acrylate, or dipentaerythritol hexa(meth)acrylate. Such polyfunctional monomers may be used singly or in combination of two or more thereof.

[0048]

The use amount of the polyfunctional monomer(s), which is varied in accordance with the molecular weight thereof, the number of functional groups thereof and others, is preferably 3 parts or less by weight, more

preferably 2 parts or less by weight, even more preferably 1 part or less for 100 parts by weight of the whole of the monofunctional monomer(s). The lower limit thereof is not particularly limited, and is preferably 0 parts or more by weight, more preferably 0.001 part or more by weight. When the use amount of the polyfunctional monomer(s) is in any one of these ranges, the pressure-sensitive-adhesive composition can be improved in adhering strength.

[0049]

In the present invention, one of the composition components may be a partially polymerized product made from the above-mentioned monomer component. The "partially polymerized product" referred to herein is a product yielded by polymerizing the monomer component in a partial quantity thereof. The polymerization rate of the partially polymerized product made from the monomer component will be as described later.

[0050]

The ultraviolet-curable acryl-based pressure-sensitive adhesive composition of the present invention includes an ultraviolet absorbent.

[0051]

The ultraviolet absorbent is not particularly limited. Examples thereof include any triazine-based ultraviolet absorbent, any benzotriazole-based ultraviolet

absorbent, any benzophenone-based ultraviolet absorbent, any oxybenzophenone-based ultraviolet absorbent, any salicylate-based ultraviolet absorbent, and any cyanoacrylate-based ultraviolet absorbent. These may be used singly or in any combination of two or more thereof. Thereamong, any triazine-based ultraviolet absorbent and any benzotriazole-based ultraviolet absorbent are preferred. The ultraviolet absorbent is preferably an ultraviolet absorbent selected from the group consisting of triazine-based ultraviolet absorbents each having, in a single molecule thereof, 2 hydroxyl groups or less, and benzotriazole-based ultraviolet absorbents each having, in a single molecule thereof, one benzotriazole skeleton since the ultraviolet absorbent is good in dissolubility into the monomer(s) used to form the acryl-based pressure-sensitive-adhesive composition, and further the ultraviolet absorbent is high in ultraviolet absorbing ability at wavelengths around 380 nm.

[0052]

Specific examples of the triazine-based ultraviolet absorbent, which has, in a single molecule thereof, 2 hydroxyl groups or less, that may also be used, include 2,4-bis-[[4-(4-ethylhexyloxy)-4-hydroxy}-phenyl]-6-(4-methoxyphenyl)-1,3,5-triazine (TINOSORB S, manufactured by BASF), 2,4-bis[2-hydroxy-4-butoxyphenyl]-6-(2,4-

dibutoxyphenyl)-1,3,5-triazine (TINUVIN 460, manufactured by BASF), a reaction product (TINUVIN 400, manufactured by BASF) produced from 2-(4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine-2-yl)-5-hydroxyphenyl and [(C10-C16 (mainly C12-C13) alkyloxy)methyl]oxirane, 2-[4,6-bis(2,4-dimethylphenyl)-1,3,5-triazine-2-yl]-5-[3-(dodecyloxy)-2-hydroxypropoxy]phenol), a reaction product (TINUVIN 405, manufactured by BASF) produced from 2-(2,4-dihydroxyphenyl)-4,6-bis-(2,4-dimethylphenyl)-1,3,5-triazine and a (2-ethylhexyl) ester of glycidic acid, 2-(4,6-diphenyl-1,3,5-triazine-2-yl)-5-[(hexyl)oxy]-phenol (TINUVIN 1577, manufactured by BASF), 2-(4,6-diphenyl-1,3,5-triazine-2-yl)-5-[2-(2-ethylhexanoyloxy)ethoxy]-phenol (ADK STAB LA46, manufactured by ADEKA Corp.), and 2-(2-hydroxy-4-[1-octyloxycarbonylethoxy]phenyl)-4,6-bis(4-phenylphenyl)-1,3,5-triazine (TINUVIN 479, manufactured by BASF).

[0053]

Examples of the benzotriazole-based ultraviolet absorbent having, in a single molecule thereof, one benzotriazole skeleton, that may also be used, include 2-(2H-benzotriazol-2-yl)-6-(1-methyl-1-phenylethyl)-4-(1,1,3,3-tetramethylbutyl) phenol (TINUVIN 928, manufactured by BASF), 2-(2-hydroxy-5-tert-butylphenyl)-2H-benzotriazole (TINUVIN PS, manufactured by BASF), an

esterified product (TINUVIN 384-2, manufactured by BASF) produced from benzenepropanoic acid and 3-(2H-benzotriazol-2-yl)-5-(1,1-dimethylethyl)-4-hydroxy(C7-9 side chain and straight chain alkyl), 2-(2H-benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol (TINUVIN 900, manufactured by BASF), 2-(2H-benzotriazol-2-yl)-6-(1-methyl-1-phenylethyl)-4-(1,1,3,3-tetramethylbutyl)phenol (TINUVIN 928, manufactured by BASF), a reaction product (TINUVIN 1130, manufactured by BASF) produced from methyl-3-(3-(2H-benzotriazol-2-yl)-5-*t*-butyl-4-hydroxyphenyl)propionate/polyethylene glycol 300, 2-(2H-benzotriazol-2-yl)-*p*-cresol (TINUVIN P, manufactured by BASF), 2-(2H-benzotriazol-2-yl)-4,6-bis(1-methyl-1-phenylethyl)phenol (TINUVIN 234, manufactured by BASF), 2-[5-chloro(2H)-benzotriazole-2-yl]-4-methyl-6-(*tert*-butyl)phenol (TINUVIN 326, manufactured by BASF), 2-(2H-benzotriazol-2-yl)-4,6-di-*tert*-pentylphenol (TINUVIN 328, manufactured by BASF), 2-(2H-benzotriazol-2-yl)-4-(1,1,3,3-tetramethylbutyl)phenol (TINUVIN 329, manufactured by BASF), a reaction product (TINUVIN 213, manufactured by BASF) produced from methyl 3-(3-(2H-benzotriazol-2-yl)-5-*tert*-butyl-4-hydroxyphenyl)propionate and polyethylene glycol 300, 2-(2H-benzotriazol-2-yl)-6-dodecyl-4-methylphenol (TINUVIN 571, manufactured by BASF), and 2-[2-hydroxy-3-(3,4,5,6-tetrahydrophthalimide-methyl)-5-

methylphenyl]benzotriazole (SUMISORB 250, manufactured by Sumitomo Chemical Co., Ltd.).

[0054]

Examples of the benzophenone-based ultraviolet absorbent (benzophenone-based compound), or the oxybenzophenone-based ultraviolet absorbent (oxybenzophenone-based compound) include 2,4-dihydroxybenzophenone, 2-hydroxy-4-methoxybenzophenone, 2-hydroxy-4-methoxybenzophenone-5-sulfonic acid (anhydride and trihydrate), 2-hydroxy-4-octyloxybenzophenone, 4-dodecyloxy-2-hydroxybenzophenone, 4-benzyloxy-2-hydroxybenzophenone, 2,2',4,4'-tetrahydroxybenzophenone, and 2,2'-dihydroxy-4,4-dimethoxybenzophenone.

[0055]

Examples of the salicylate-based ultraviolet absorbent (salicylate-based compound) include phenyl-2-acryloyloxybenzoate, phenyl-2-acryloyloxy-3-methylbenzoate, phenyl-2-acryloyloxy-4-methylbenzoate, phenyl-2-acryloyloxy-5-methylbenzoate, phenyl-2-acryloyloxy-3-methoxybenzoate, phenyl-2-hydroxybenzoate, phenyl-2-hydroxy-3-methylbenzoate, phenyl-2-hydroxy-4-methylbenzoate, phenyl-2-hydroxy-5-methylbenzoate, phenyl-2-hydroxy-3-methoxybenzoate, 2,4-di-tert-butylphenyl-3,5-di-tert-butyl-4-hydroxybenzoate (TINUVIN 120, manufactured by BASF).

[0056]

Examples of the cyanoacrylate-based ultraviolet absorbent (cyanoacrylate-based compound) include alkyl-2-cyanoacrylate, cycloalkyl-2-cyanoacrylate, alkoxyalkyl-2-cyanoacrylate, alkenyl-2-cyanoacrylate, and alkynyl-2-cyanoacrylate.

[0057]

The above-mentioned ultraviolet absorbents may be used singly, or in the form of a mixture of two or more thereof. The total content of the absorbent(s) is preferably from about 0.1 to 5 parts by weight, more preferably about 0.5 to 3 parts by weight for 100 parts by weight of the monofunctional monomer component(s), from which the (meth)acryl-based polymer is made. When the addition amount of the ultraviolet absorbent(s) is set in any one of these ranges, favorably, the pressure-sensitive adhesive layer can sufficiently exhibit an ultraviolet absorbing function and additionally the ultraviolet-ray-polymerization is not hindered.

[0058]

The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition is a composition including a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more. The photopolymerization initiator (A) having an absorption band at wavelengths of

400 nm or more is sufficient to be a photopolymerization initiator having an absorption band at wavelengths of 400 nm or more, and may have an absorption band at wavelengths less than 400 nm. In a case where a pressure-sensitive-adhesive composition includes an ultraviolet absorbent, the ultraviolet absorbent unfavorably absorbs ultraviolet rays when the composition is subjected to ultraviolet polymerization. Thus, the polymerization cannot be sufficiently attained. However, the pressure-sensitive-adhesive composition of the present invention has the photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more. Therefore, the monomer component(s) in this composition can be sufficiently polymerized although the composition includes the ultraviolet absorbent.

[0059]

Examples of the photopolymerization initiator (A), which has an absorbing band in wavelengths of 400 nm or more, include bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide (IRGACURE 819, manufactured by BASF), and 2,4,6-trimethylbenzoyl-diphenyl-phosphine oxide (LUCIRIN TPO, manufactured by BASF).

[0060]

Such photopolymerization initiators (A), which each have an absorbing band in wavelengths of 400 nm or more,

may be used singly or in the form of a mixture of two or more thereof.

[0061]

The addition amount of the photopolymerization initiator(s) (A), which (each) has/have an absorbing band in wavelengths of 400 nm or more, is not particularly limited, and is preferably smaller than that of the ultraviolet absorbent. The addition amount is preferably from about 0.005 to 1 part by weight, more preferably from about 0.02 to 0.5 part by weight for 100 parts by weight of the monofunctional monomer(s), from which the (meth)acryl-based polymer is made. When the addition amount of the photopolymerization initiator(s) (A) is in any one of these ranges, the ultraviolet polymerization can be favorably advanced.

[0062]

The ultraviolet-curable acryl-based pressure-sensitive adhesive composition of the present invention may include a photopolymerization initiator (B) having an absorbing band in wavelengths less than 400 nm. It is preferred that the photopolymerization initiator (B) has no absorption band in wavelengths of 400 nm or more. The photopolymerization initiator (B) is not particularly limited as far as the initiator is an initiator which is irradiated with ultraviolet rays to generate radicals to

initiate photopolymerization, and which has an absorbing band in wavelengths less than 400 nm. Any one of such photopolymerization initiators that are ordinarily used is preferably usable. For example, any one of the following is usable: any benzoin ether-based photopolymerization initiator, any acetophenone-based photopolymerization initiator, any  $\alpha$ -ketol-based photopolymerization initiator, any optically active oxime-based photopolymerization initiator, any benzoin-based photopolymerization initiator, any benzil-based photopolymerization initiator, any benzophenone-based photopolymerization initiator, any ketal-based photopolymerization initiator, any thioxanthone-based photopolymerization initiator, and any acylphosphine oxide-based photopolymerization initiator.

[0063]

Specific examples of the benzoin ether-based photopolymerization initiator include benzoin methyl ether, benzoin ethyl ether, benzoin propyl ether, benzoin isopropyl ether, benzoin isobutyl ether, 2,2-dimethoxy-1,2-diphenylethane-1-one, and anisole methyl ether.

[0064]

Examples of the acetophenone-based photopolymerization initiator include 2,2-diethoxyacetophenone, 2,2-dimethoxy-2-phenylacetophenone,

1-hydroxycyclohexyl phenyl ketone, 4-phenoxydichloroacetophenone, and 4-t-butyl-dichloroacetophenone.

[0065]

Examples of the  $\alpha$ -ketol-based photopolymerization initiator include 2-methyl-2-hydroxypropiophenone, and 1-[4-(2-hydroxyethyl)phenyl]-2-hydroxy-2-methylpropane-1-one.

[0066]

An example of the optically active oxime-based photopolymerization initiator is 1-phenyl-1,2-propanedione-2-(o-ethoxycarbonyl)-oxime.

[0067]

An example of the benzoin-based photopolymerization initiator is benzoin.

[0068]

Examples of the benzil-based photopolymerization initiator include benzil.

[0069]

Examples of the benzophenone-based photopolymerization initiator include benzophenone, benzoylbenzoic acid, 3,3'-dimethyl-4-methoxybenzophenone, polyvinylbenzophenone, and  $\alpha$ -hydroxycyclohexyl phenyl ketone.

[0070]

Examples of the ketal-based photopolymerization

initiator include benzyl dimethyl ketal.

[0071]

Examples of the thioxanthone-based photopolymerization initiator include thioxanthone, 2-chlorothioxanthone, 2-methylthioxanthone, 2,4-dimethylthioxanthone, isopropylthioxanthone, 2,4-dichlorothioxanthone, 2,4-diethylthioxanthone, 2,4-diisopropylthioxanthone, and dodecyl thioxanthone.

[0072]

Examples of the acylphosphine oxide-based photopolymerization initiator include 2,4,6-trimethylbenzoyl-diphenyl-phosphine oxide, and bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide.

[0073]

Such photopolymerization initiators (B), which each have an absorbing band in wavelengths less than 400 nm, may be used singly or in any combination of two or more thereof. The photopolymerization initiator(s) (B), which has/have an absorbing band in wavelengths less than 400 nm, may be added to the pressure-sensitive-adhesive composition as far as the advantageous effects of the present invention are not damaged. The addition amount thereof is preferably from about 0.005 to 0.5 parts by weight, more preferably from about 0.02 to 0.1 part by weight for 100 parts by weight of the monofunctional monomer component(s), from

which the (meth)acryl-based polymer is made.

[0074]

In the present invention, it is preferred to add the photopolymerization initiator (B), which has an absorbing band in wavelengths less than 400 nm, earlier to the monomer component(s); radiate ultraviolet rays to the resultant to polymerize the monomer component(s); add, to the resultant partially polymerized product (prepolymer composition) of the monomer component(s), a photopolymerization initiator (A) as described above, which has an absorbing band in wavelengths of 400 nm or more, and an ultraviolet absorbent; and polymerize the resultant by effect of ultraviolet rays. When the photopolymerization initiator (A), which has an absorbing band in wavelengths of 400 nm or more, is added to the partially polymerized product (prepolymer composition) of the monomer component(s), in which the component(s) has/have been partially polymerized by effect of the ultraviolet rays, it is preferred to dissolve the photopolymerization initiator into the monomer(s) and subsequently add the resultant solution thereto.

[0075]

Furthermore, the ultraviolet-curable acryl-based pressure-sensitive adhesive composition of the present invention may contain a silane coupling agent. The blend

amount of the silane coupling agent is preferably 1 part or less by weight, more preferably from 0.01 to 1 part by weight, even more preferably from 0.02 to 0.6 part by weight for 100 parts by weight of the monofunctional monomer component(s), from which the (meth)acryl-based polymer is made.

[0076]

Examples of the silane coupling agent include epoxy-group-containing silane coupling agents such as 3-glycidoxypropyltrimethoxysilane, 3-glycidoxypropyltriethoxysilane, 3-glycidoxypropylmethyldiethoxysilane, and 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane; amino-group-containing silane coupling agents such as 3-aminopropyltrimethoxysilane, N-2-(aminoethyl)-3-aminopropylmethyldimethoxysilane, 3-triethoxysilyl-N-(1,3-dimethylbutylidene)propylamine, and N-phenyl- $\gamma$ -aminopropyltrimethoxysilane; (meth)acrylic-group-containing silane coupling agents such as 3-acryloyloxypropyltrimethoxysilane, and 3-methacryloyloxypropyltriethoxysilane; and isocyanate-group-containing silane coupling agents such as 3-isocyanatopropyltriethoxysilane.

[0077]

The ultraviolet-curable acryl-based pressure-

sensitive adhesive composition of the present invention may contain a crosslinking agent. Examples of the crosslinking agent include isocyanate-based crosslinking agents, epoxy-based crosslinking agents, silicone-based crosslinking agents, oxazoline-based crosslinking agents, aziridine-based crosslinking agents, silane-based crosslinking agents, alkyl-etherified melamine-based crosslinking agents, metal chelate-based crosslinking agents, and peroxide crosslinking agents. These crosslinking agents may be used singly or in any combination of two or more thereof. Thereamong, isocyanate-based crosslinking agents are preferred.

[0078]

The crosslinking agents may be used singly or in the form of a mixture of two or more thereof. The content of the whole of the crosslinking agent(s) is preferably 5 parts or less by weight, more preferably from 0.01 to 5 parts by weight, even more preferably from 0.01 to 4 parts by weight, in particular preferably from 0.02 to 3 parts by weight for 100 parts by weight of the monofunctional monomer component(s), from which the (meth)acryl-based polymer is made.

[0079]

The isocyanate-based crosslinking agents each denote a compound having, in a single molecule thereof, two or

more isocyanate groups (the groups may be isocyanate-reproducing type functional groups yielded by protecting isocyanate groups temporarily with a blocking agent or temporarily through, for example, multimer conversion thereof). Examples of the isocyanate crosslinking agents include aromatic isocyanates such as tolylene diisocyanate and xylene diisocyanate; alicyclic isocyanates such as isophorone diisocyanate; and aliphatic isocyanates such as hexamethylene diisocyanate.

[0080]

More specific examples thereof include lower aliphatic polyisocyanates such as butylene diisocyanate and hexamethylene diisocyanate; alicyclic isocyanates such as cyclopentylene diisocyanate, cyclohexylene diisocyanate, and isophorone diisocyanate; aromatic diisocyanates such as 2,4-tolylene diisocyanate, 4,4'-diphenylmethane diisocyanate, xylylene diisocyanate, and polymethylene polyphenyl isocyanate; isocyanate adducts such as a trimethylolpropane-tolylene diisocyanate trimer adduct (trade name: CORONATE L, manufactured by NIPPON POLYURETHANE INDUSTRY CO., LTD.), a trimethylolpropane-hexamethylene diisocyanate trimer adduct (trade name: CORONATE HL, manufactured by NIPPON POLYURETHANE INDUSTRY CO., LTD.), and an isocyanurate of hexamethylene diisocyanate (trade name: CORONATE HX, manufactured by

NIPPON POLYURETHANE INDUSTRY CO., LTD.); a trimethylolpropane adduct of xylylene diisocyanate (trade name: D110N, manufactured by Mitsui Chemicals, Inc.) and a trimethylolpropane adduct of hexamethylene diisocyanate (trade name: D160N, manufactured by Mitsui Chemicals, Inc.); polyether polyisocyanate and polyester polyisocyanate; adducts thereof with various polyols; and polyisocyanates polyfunctionalized with an isocyanurate bond, a biuret bond, an allophanate bond, or the like.

[0081]

The ultraviolet-curable acryl-based pressure-sensitive adhesive composition of the present invention may contain, besides the above-mentioned components, an appropriate additive in accordance with the use of the composition. Examples thereof include tackifiers (each made of a material that is in a solid, semi-solid or liquid form at room temperature and that is made of, for example, a rosin derivative resin, a polyterpene resin, a petroleum resin or an oil-soluble phenol resin); fillers such as hollow glass balloons; plasticizers; antiaging agents; and antioxidants.

[0082]

In the present invention, it is preferred to adjust the ultraviolet-curable acryl-based pressure-sensitive adhesive composition to a viscosity suitable for works of

this composition, such as an application thereof onto a substrate. The adjustment of the viscosity of the ultraviolet-curable acryl-based pressure-sensitive adhesive composition is made by, for example, the addition of a tackifying additive, any other polymer or polyfunctional monomer that may be of various types, or the like, or by a partial polymerization of one or more monomer component(s) in the ultraviolet-curable acryl-based pressure-sensitive adhesive composition. The partial polymerization may be performed before or after the addition of the tackifying additive, the other polymer or polyfunctional monomer, which may be of various types, or the like. The viscosity of the ultraviolet-curable acryl-based pressure-sensitive adhesive composition is varied in accordance with, for example, the amount of the additive. Thus, when the monomer component(s) in the ultraviolet-curable acryl-based pressure-sensitive adhesive composition is/are partially polymerized, the polymerization rate cannot be specified. However, as a guide, the polymerization rate is preferably about 20% or less, more preferably from about 3 to 20%, even more preferably from about 5 to 15%. If the polymerization rate is more than 20%, the partially polymerized product is excessively high in viscosity not to be easily applied onto a substrate.

[0083]

The transmissible  $b^*$  value of the pressure-sensitive-adhesive layer, which is formed by the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the invention, is not particularly limited, and is preferably 3.0 or less, more preferably 1.5 or less, even more preferably 0.5 or less. The  $b^*$  value denotes a  $b^*$  value (chromaticity) in an  $L^*a^*b^*$  color coordinate system according to JIS Z8729, and is measurable, using, for example, a spectrophotometer (product name: U4100, manufactured by Hitachi High-Technologies Corp.).

[0084]

At a wavelength of 380 nm, the transmittance of the pressure-sensitive-adhesive layer, which is formed by the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the invention, is 40% or less, preferably 20% or less, more preferably 8% or less. When the transmittance at the wavelength of 380 nm is in any one of the ranges, this layer can block incident ultraviolet rays sufficiently to restrain deteriorations of the liquid crystal panel, the organic electroluminescent element, the polarizer, and other optical members in the present invention.

[0085]

At a wavelength of 400 nm, the transmittance of the pressure-sensitive-adhesive layer, which is formed by the

ultraviolet-curable acryl-based pressure-sensitive-adhesive composition of the invention, is 30% or more, preferably 50% or more, more preferably 70% or more. When the transmittance at the wavelength of 400 nm is in any one of the ranges, this layer can transmit incident visible light sufficiently so that the image display device can favorably ensure a sufficient viewability.

[0086]

## 2. Ultraviolet-Curable Acryl-Based Pressure-Sensitive-Adhesive Layer

The ultraviolet-curable acryl-based pressure-sensitive-adhesive layer of the present invention is a pressure-sensitive-adhesive layer positioned between a cover glass or cover plastic, and a polarizing film in an image display device; and

this layer is formed by radiating an ultraviolet ray to the above-defined ultraviolet-curable acryl-based pressure-sensitive-adhesive composition to photopolymerize the monomer component in the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition.

[0087]

The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition may be the same composition as described above.

[0088]

The illuminance of the radiated ultraviolet rays to the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition is preferably 5 mW/cm<sup>2</sup> or more. If the illuminance of the ultraviolet rays is less than 5 mW/cm<sup>2</sup>, the polymerization reaction period may become long to deteriorate the layer in productivity. The illuminance of the ultraviolet rays is preferably 200 mW/cm<sup>2</sup> or less. If the illuminance of the ultraviolet rays is more than 200 mW/cm<sup>2</sup>, the photopolymerization initiator is abruptly consumed so that the polymer may be lowered in molecular weight. Consequently, the holding strength may be lowered, particularly, at high temperatures. The integrated value of the ultraviolet rays is preferably from 100 mJ/cm<sup>2</sup> to 5000 mJ/cm<sup>2</sup>.

[0089]

An ultraviolet lamp used in the present invention is not particularly limited, and is preferably an LED lamp. The LED lamp is a lamp lower in radiated heat than other ultraviolet lamps. Thus, the LED lamp allows to control the temperature of the pressure-sensitive-adhesive layer in the polymerization into a low level. Consequently, the polymer can be prevented from being lowered in molecular weight, and the pressure-sensitive-adhesive layer can be prevented from being lowered in cohesive strength. Additionally, when the pressure-sensitive-adhesive

composition is made into a pressure-sensitive adhesive sheet, the holding strength at high temperatures can be made high. Plural ultraviolet lamps may be combined with each other. The ultraviolet rays may be intermittently radiated to set a period when the ultraviolet rays are radiated and a period when no ultraviolet rays are radiated.

[0090]

In the present invention, the final polymerization rate of the monomer component(s) in the ultraviolet-curable pressure-sensitive-adhesive composition is preferably 90% or more, more preferably 95% or more, even more preferably 98% or more.

[0091]

In the present invention, the wavelength of a peak of the ultraviolet rays radiated to the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition is in a range preferably from 200 to 500 nm, more preferably from 300 to 450 nm. If the peak wavelength of the ultraviolet rays is more than 500 nm, the photopolymerization initiator may not be decomposed so that no polymerization reaction is initiated. If the peak wavelength of the ultraviolet rays is less than 200 nm, the polymer chain may be cleaved so that the resultant may be lowered in adhesive property.

[0092]

In order that the layer can ensure an ultraviolet absorbing function, the thickness of the pressure-sensitive-adhesive layer of the present invention is preferably 50  $\mu\text{m}$  or more, more preferably 100  $\mu\text{m}$  or more, even more preferably 150  $\mu\text{m}$  or more. The upper limit value of the thickness of the pressure-sensitive-adhesive layer is not particularly limited, and is preferably 10 mm or less. If the thickness of the pressure-sensitive-adhesive layer is more than 10 mm, the layer does not transmit ultraviolet rays easily so that a long time is required for the polymerization of the monomer component(s).

Accordingly, the productivity may be unfavorably poor.

[0093]

The gel fraction in the pressure-sensitive-adhesive layer of the present invention is not particularly limited, and is preferably 50% or more, more preferably 75% or more, even more preferably 85% or more. If the gel fraction in the pressure-sensitive-adhesive layer is small, the layer is poor in cohesive strength. If the gel fraction in the pressure-sensitive-adhesive layer is too large, the layer is poor in adhering strength.

[0094]

The transmission  $b^*$  value of the pressure-sensitive-adhesive layer, and the transmittance thereof at a wavelength of 380 nm and the transmittance thereof at a

wavelength of 400 nm are as described above.

[0095]

The pressure-sensitive-adhesive layer of the present invention is a layer used in an image display device. More specifically, the pressure-sensitive-adhesive layer is a layer positioned between a cover glass or cover plastic and a polarizing film in the image display device. When the pressure-sensitive-adhesive layer of the invention is preset at this position, the pressure-sensitive-adhesive layer can exhibit a sufficient ultraviolet absorbing function.

[0096]

### 3. Pressure-sensitive-adhesive layer-attached Polarizing Film

The pressure-sensitive-adhesive layer-attached polarizing film of the present invention includes a polarizing film, and the above-defined ultraviolet-curable acryl-based pressure-sensitive-adhesive layer provided on at least one surface of the polarizing film.

[0097]

A method for forming the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer is as described above. This pressure-sensitive-adhesive layer may be formed by applying the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition directly onto a

polarizing film, or may be formed on a polarizing film by forming a pressure-sensitive-adhesive layer onto, for example, a release film, and subsequently transferring this pressure-sensitive-adhesive layer onto the polarizing film.

[0098]

The polarizing film is preferably a polarizing film having a polarizer and a transparent protective film on at least one surface of this polarizer.

[0099]

The polarizer is not particularly limited, and may be a polarizer of various types. For example, the polarizer may be a product produced by a process including adsorbing a dichroic material such as iodine or a dichroic dye to a hydrophilic polymer film such as a polyvinyl alcohol-based film, a partially-formalized polyvinyl alcohol-based film, or a partially-saponified, ethylene-vinyl acetate copolymer-based film and uniaxially stretching the film, or may be a polyene-based oriented film such as a film of a dehydration product of polyvinyl alcohol or a dehydrochlorination product of polyvinyl chloride. Among these polarizers, a polarizer including a polyvinyl alcohol-based film and a dichroic material such as iodine is preferred. The thickness of these polarizers is not particularly limited, and is generally from about 5 to 80  $\mu\text{m}$ .

[0100]

The polarizer yielded by dyeing a polyvinyl alcohol based film with iodine, and then stretching the resultant uniaxially may be produced, for example, by immersing a polyvinyl alcohol into an aqueous solution of iodine to dye the polyvinyl alcohol, and then stretching the resultant into a length 3 to 7 times the original length. If necessary, the film may also be immersed in an aqueous solution of potassium iodide or the like optionally containing boric acid, zinc sulfate, zinc chloride, or other materials. If necessary, the polyvinyl alcohol-based film may be further immersed in water for washing before it is dyed. If the polyvinyl alcohol-based film is washed with water, dirt and any anti-blocking agent can be cleaned from the surface of the polyvinyl alcohol-based film, and the polyvinyl alcohol-based film can also be allowed to swell so that unevenness such as uneven dyeing can be effectively prevented. The film may be stretched before, while, or after it is dyed with iodine. The film may also be stretched in an aqueous solution of boric acid, potassium iodide, or the like or in a water bath.

[0101]

In the present invention, a thin polarizer of 10  $\mu\text{m}$  or less thickness may be used. For making the polarizing film thinner, the thickness is preferably from 1 to 7  $\mu\text{m}$ .

Such a thin polarizer is preferred in the point that the polarizer is small in thickness unevenness, excellent in visibility, and small in dimension change to be excellent in endurance and further the thickness of the polarizing film is also made smaller.

[0102]

Typical examples of the thin polarizer include thin polarizing membranes described in JP-A-S51-069644, JP-A-2000-338329, WO2010/100917 pamphlet, WO2010/100917 pamphlet, JP-B1-4751481, and JP-A-2012-73563. These thin polarizing membranes can each be yielded by a producing method including the step of stretching a polyvinyl alcohol-based resin (hereinafter referred to as a PVA-based resin) and a resin substrate for stretching in a laminated state, and the step of dyeing the laminate. This producing method makes it possible to stretch the laminate, even when this layer is thin, without causing any inconvenience, such as breaking, by the stretching based on the supporting of the PVA-based resin layer on the resin substrate for stretching.

[0103]

The thin polarizing membranes are preferably polarizing membranes each yielded by the following producing method, out of producing methods including the step of stretching the members concerned in the laminate

state and the step of dyeing the laminate, since the laminate can be stretched into a large stretch ratio to improve the resultant in polarizing performance: a producing method including the step of stretching the laminating in an aqueous solution of boric acid, as is described in WO 2010/100917 pamphlet, WO2010/100917 pamphlet, JP-B1-4751481, or JP-A-2012-073563; and the membranes are in particular preferably membranes each yielded by a producing method including the step of stretching the laminate supplementally in the air before the stretching in the aqueous solution of boric acid, as is described in JP-B1-4751481, or JP-A-2012-073563.

[0104]

The transparent protective film or films on one or both sides of the polarizer are preferably made of a material having a high level of transparency, mechanical strength, thermal stability, water barrier properties, isotropy, and other properties. Examples of such a material include polyester polymers such as polyethylene terephthalate and polyethylene naphthalate, cellulose polymers such as diacetyl cellulose and triacetyl cellulose, acryl-based polymers such as polymethyl methacrylate, styrene polymers such as polystyrene and acrylonitrile-styrene copolymers (AS resins), polycarbonate polymers, etc. Examples of polymers that may be used to

form the transparent protective films also include polyolefin polymers such as polyethylene, polypropylene, cyclo- or norbornene-structure-containing polyolefin, and ethylene-propylene copolymers, vinyl chloride polymers, amide polymers such as nylon and aromatic polyamide, imide polymers, sulfone polymers, polyether sulfone polymers, polyether ether ketone polymers, polyphenylene sulfide polymers, vinyl alcohol polymers, vinylidene chloride polymers, vinyl butyral polymers, arylate polymers, polyoxymethylene polymers, epoxy polymers, or any blends of the above polymers. The transparent protective film may also be a layer formed by curing a curable resin such as a thermosetting or ultraviolet-curable resin such as an acrylic, urethane, acrylic urethane, epoxy, or silicone resin.

[0105]

The thickness of the protective film may be determined as appropriate. Generally, the thickness of the protective film is from about 1 to about 500  $\mu\text{m}$  in view of strength, workability such as handleability, and thin film formability.

[0106]

The polarizer and the protective film are generally bonded with a water-based adhesive or the like interposed therebetween. Examples of the water-based adhesive include

isocyanate adhesives, polyvinyl alcohol-based adhesives, gelatin-based adhesives, vinyl-based latex-based adhesives, water-based polyurethane adhesives, and water-based polyester adhesives. Besides the above, ultraviolet-curable adhesives, electron beam-curable adhesives, or the like may also be used to bond the polarizer and the transparent protective film together. Electron beam-curable adhesives for polarizing films have good tackiness to the various transparent protective films described above. The adhesive for use in the invention may also contain a metal compound filler.

[0107]

The surface of the transparent protective film opposite to its surface to be bonded to the polarizer may have undergone the formation of a hard coat layer, an anti-reflection treatment, an anti-sticking treatment, or a treatment for diffusion or antiglare properties.

[0108]

When the surface of the pressure-sensitive adhesive layer of the pressure-sensitive-adhesive-layer-attached polarizing film of the invention is exposed, the pressure-sensitive adhesive layer may be protected by a release film (separator) until it is actually used. Examples of the release film include those listed above. When a release film is used as the substrate on which the pressure-

sensitive adhesive layer is formed, the polarizing film may be bonded to the pressure-sensitive adhesive layer on the release film, so that the release film can be used as it is for the pressure-sensitive adhesive layer of the pressure-sensitive adhesive layer-attached polarizing film, which can simplify the process.

[0109]

#### 4. Method for Producing Pressure-Sensitive-Adhesive Layer

The present invention relates to a method for producing an ultraviolet-curable acryl-based pressure-sensitive-adhesive layer formed from an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition including a photopolymerization initiator (B), the method including:

the step of radiating a composition including a monomer component including an alkyl (meth)acrylate, and the photopolymerization initiator (B) to produce a partially polymerized product made from the monomer component;

the step of adding an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more to the partially polymerized product made from the monomer component to produce an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition; and

the step of applying the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition to at least one surface of a substrate, and radiating an ultraviolet ray to the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition.

[0110]

The individual components included in the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition are as described above.

[0111]

When the pressure-sensitive-adhesive layer is formed from the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition including a photopolymerization initiator (B), ultraviolet rays are initially radiated to a composition including an alkyl-(meth)acrylate-including monomer component and the photopolymerization initiator (B) (referred to also as the "earlier-adding polymerization initiator") to produce a partially polymerized product made from the monomer component. The polymerization rate of the partially polymerized product is preferably about 20% or less, more preferably from about 3 to 20%, even more preferably from about 5 to 15%. Conditions for the radiation of the ultraviolet rays are as described above.

[0112]

Subsequently, to the partially polymerized product made from the monomer component are added an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more (referred to also as an "afterward-adding polymerization initiator") to produce an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition. The ultraviolet absorbent, the photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more, and the respective amounts thereof are as described above.

[0113]

The thus-obtained ultraviolet-curable acryl-based pressure-sensitive-adhesive composition is applied onto at least one surface of a substrate, and then this ultraviolet-curable acryl-based pressure-sensitive-adhesive composition is irradiated with ultraviolet rays. In this way, an ultraviolet-curable acryl-based pressure-sensitive-adhesive layer can be produced. Conditions for the radiation of the ultraviolet rays are as described above.

[0114]

The substrate is not particularly limited, and may be a substrate that may be of various types, examples thereof including a release film, and a transparent resin film substrate. A polarizing film that will be detailed later is also usable as the substrate.

[0115]

Examples of the material for forming the release film include a plastic film such as a polyethylene, polypropylene, polyethylene terephthalate, or polyester film, a porous material such as paper, cloth and nonwoven fabric, and an appropriate thin material such as a net, a foamed sheet, a metal foil, and a laminate thereof. In particular, a resin film is preferably used, because of its good surface smoothness.

[0116]

Examples of the resin film include a polyethylene film, a polypropylene film, a polybutene film, a polybutadiene film, a polymethylpentene film, a polyvinyl chloride film, a vinyl chloride copolymer film, a polyethylene terephthalate film, a polybutylene terephthalate film, a polyurethane film, and an ethylene-vinyl acetate copolymer film.

[0117]

The thickness of the release film is generally from about 5 to about 200  $\mu\text{m}$ , preferably from about 5 to about 100  $\mu\text{m}$ . If necessary, the release film may be treated with a release agent such as a silicone, fluorine, long-chain alkyl, or fatty acid amide release agent, or may be subjected to release and antifouling treatment with silica powder or to antistatic treatment of coating type, kneading and mixing

type, vapor-deposition type, or the like. In particular, if the surface of the release film is appropriately subjected to release treatment such as silicone treatment, long-chain alkyl treatment, and fluorine treatment, the releasability from the pressure-sensitive adhesive layer can be further increased.

[0118]

The transparent resin film substrate to be used may be, but not limited to, various transparent resin films. The resin film is generally formed of a monolayer film. Examples of the material for the transparent resin film substrate include polyester resins such as polyethylene terephthalate and polyethylene naphthalate, acetate resins, polyethersulfone resins, polycarbonate resins, polyamide resins, polyimide resins, polyolefin resins, (meth) acrylic resins, polyvinyl chloride resins, polyvinylidene chloride resins, polystyrene resins, polyvinyl alcohol resins, polyarylate resins, and polyphenylene sulfide resins. In particular, polyester resins, polyimide resins, and polyethersulfone resins are preferred.

[0119]

The film substrate preferably has a thickness of 15 to 200  $\mu\text{m}$ , more preferably 25 to 188  $\mu\text{m}$ .

[0120]

The method for applying the ultraviolet-curable

acryl-based pressure-sensitive-adhesive composition onto the substrate is not particularly limited, and may be an appropriate known method, such as roll coating, bar coating, or a die coater.

[0121]

The reaction is hindered by oxygen in air. Thus, in order to shut out oxygen, it is preferred to form, for example, a release film onto an applied film made of the acryl-based pressure-sensitive-adhesive composition, or to conduct the photopolymerization reaction in the atmosphere of nitrogen. The release film may be a release film as described above.

[0122]

As described above, when the pressure-sensitive-adhesive layer is formed from the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition including the photopolymerization initiator (B), it is preferred to add the photopolymerization initiator (B) initially to the other components to produce a partially polymerized product made from the monomer component, and add, to the partially polymerized product, the ultraviolet absorbent and the photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more afterward to produce the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition. The two-stage

polymerization in this way allows to raise the polymerization rate of the monomer component, and further improve the finally-produced pressure-sensitive-adhesive layer in ultraviolet absorbing function.

[0123]

## 5. Image Display Device

The image display device of the present invention has at least a cover glass or cover plastic, and a polarizing film,

this display device having the above-defined pressure-sensitive-adhesive layer positioned between the cover glass or cover plastic and the polarizing film.

[0124]

The image display device is a device having at least one polarizing film, and at least one cover glass or cover plastic. A specific structure thereof is as described above. Examples of the image display device include liquid crystal display devices, organic electroluminescent (EL) display devices, plasma display panels (PDP), and electronic paper pieces. Thereamong, preferred are liquid crystal display devices and organic electroluminescent (EL) display devices each having a structure as described above.

## EXAMPLES

[0125]

Hereinafter, the present invention will be specifically described by way of examples thereof. However, the invention is not limited by these examples. In each of the examples, the word "part(s)" and the symbol "%" represent "part(s) by weight" and "% by weight", respectively. The following estimations were made on each of the items in Examples and so on.

[0126]

Production Example 1 (Production of Acryl-Based Pressure-Sensitive-Adhesive Composition (a-1))

Into a monomer mixture composed of 78 parts by weight of 2-ethylhexyl acrylate (2EHA), 18 parts by weight of N-vinyl-2-pyrrolidone (NVP), and 4 parts by weight of 2-hydroxyethyl acrylate (HEA) were blended 0.035 parts by weight of 1-hydroxycyclohexyl phenyl ketone (trade name: Irgacure 184, manufactured by the company BASF), and 0.035 parts by weight of 2,2-dimethoxy-1,2-diphenylethane-1-one (trade name: Irgacure 651, manufactured by the company BASF) as photopolymerization initiators ("earlier-adding polymerization initiator"). Subsequently, the resultant blend was irradiated with ultraviolet rays until the blend came to have a viscosity of about 20 Pa·s (measuring conditions: a BH viscometer, No. 5 rotor at 10 rpm and a measuring temperature of 30°C). In this way, a prepolymer composition was yielded (polymerization rate: 8%), in which

the monomer component was polymerized in a partial quantity thereof. Next, to the prepolymer composition were added 0.15 parts by weight of hexanediol diacrylate (HDDA) and 0.3 parts by weight of a silane coupling agent (trade name: KBM-403, manufactured by Shin-Etsu Chemical Co., Ltd.), and these components were mixed with each other. The mixture was irradiated with ultraviolet rays to yield an acryl-based pressure-sensitive-adhesive composition (a-1).

[0127]

#### Production Example 2 (Production of Acryl-Based Pressure-Sensitive-Adhesive Composition (a-2))

Into a four-necked flask were charged 67 parts by weight of butyl acrylate (BA), 14 parts by weight of cyclohexyl acrylate (CHA), 19 parts by weight of 4-hydroxybutyl acrylate (4HBA), and 0.09 parts by weight of 2,2-dimethoxy-1,2-diphenylethan-1-one (trade name: Irgacure 651, manufactured by BASF Japan Ltd.) and 0.09 parts by weight of 1-hydroxy-cyclohexyl-phenyl-ketone (trade name: Irgacure 184, manufactured by BASF Japan Ltd.) as photopolymerization initiators. This system was exposed to ultraviolet rays in a nitrogen atmosphere to photopolymerize the monomer components in a partial quantity thereof. In this way, a partially polymerized product (monomer syrup) was yielded which had a polymerization rate of 10%. Next, to the partially

polymerized product were added 0.15 parts by weight of dipentaerythritol penta- and hexa-acrylates (DPHA) and 0.3 parts by weight of a silane coupling agent (trade name: KBM-403, manufactured by Shin-Etsu Chemical Co., Ltd.), and these components were mixed with each other. The mixture was irradiated with ultraviolet rays to yield an acryl-based pressure-sensitive-adhesive composition (a-2).

[0128]

#### Example 1

To the acryl-based pressure-sensitive-adhesive composition (a-1) were added 1.4 parts by weight of 2,4-bis-[[4-(4-ethylhexyloxy)-4-hydroxy]-phenyl]-6-(4-methoxyphenyl)-1,3,5-triazine (trade name: Tinosorb S, manufactured by BASF Japan Ltd.) dissolved to butyl acrylate to give a solid content of 15%, and 0.2 parts by weight of bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide (trade name: Irgacure 819, manufactured by BASF Japan Ltd.) as an afterward-adding polymerization initiator. These components were then stirred to yield an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition.

[0129]

The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition was applied onto a release-treatment-applied surface of a release film to give a

thickness of 150  $\mu\text{m}$  after the composition would be made into a pressure-sensitive-adhesive layer. In this way, a applied layer was formed. Next, a release film was bonded onto the outer surface of the applied layer. Thereafter, ultraviolet rays were radiated onto the workpiece under conditions of an illuminance of  $6.5 \text{ mW/cm}^2$ , and a light quantity of  $1500 \text{ mJ/cm}^2$  to cure the applied layer optically. In this way, a pressure-sensitive adhesive sheet was formed in which the resultant pressure-sensitive adhesive layer had, on both surfaces thereof, the release films, respectively.

[0130]

Examples 2 to 16, and Comparative Examples 1 to 6

In each of the examples, an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition was prepared, and then each pressure-sensitive adhesive sheet was formed in the same manner as in Example 1 except that the following were set as shown in Table 1: the species of the used acryl-based pressure-sensitive-adhesive composition; the respective species and addition amounts of the ultraviolet absorbent and the afterward-adding photopolymerization initiator; and the thickness of the pressure-sensitive-adhesive layer after the formation of this layer. However, as shown in Table 2, in each of Comparative Examples 5 and 6, the acryl-based pressure-

sensitive-adhesive composition and the ultraviolet absorbent were bad in solubility, so that no pressure-sensitive adhesive sheet was formed although the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition was prepared.

[0131]

[Table 1]

|                       | Acryl-based pressure-sensitive-adhesive composition species | Ultraviolet absorbers (parts by weight) |            |        | Afterward-adding photopolymerization initiator (part(s) by weight) |             |             | Thickness (μm) |
|-----------------------|-------------------------------------------------------------|-----------------------------------------|------------|--------|--------------------------------------------------------------------|-------------|-------------|----------------|
|                       |                                                             | Tinosorb S                              | Tinuvin928 | LA-F70 | KEMISORB279                                                        | Irgacure819 | Irgacure651 |                |
| Example 1             | a-1                                                         | 1.4                                     |            |        |                                                                    | 0.20        |             | 150            |
| Example 2             | a-1                                                         | 0.9                                     |            |        |                                                                    | 0.20        |             | 150            |
| Example 3             | a-1                                                         | 0.6                                     |            |        |                                                                    | 0.12        |             | 150            |
| Example 4             | a-1                                                         | 2.0                                     |            |        |                                                                    | 0.80        |             | 150            |
| Example 5             | a-1                                                         | 3.0                                     |            |        |                                                                    | 0.90        |             | 150            |
| Example 6             | a-1                                                         | 0.6                                     |            |        |                                                                    | 0.12        |             | 50             |
| Example 7             | a-1                                                         | 0.6                                     |            |        |                                                                    | 0.12        |             | 75             |
| Example 8             | a-1                                                         | 0.6                                     |            |        |                                                                    | 0.12        |             | 100            |
| Example 9             | a-1                                                         | 0.9                                     |            |        |                                                                    | 0.20        |             | 100            |
| Example 10            | a-1                                                         | 1.2                                     |            |        |                                                                    | 0.20        |             | 100            |
| Example 11            | a-1                                                         | 0.6                                     |            |        |                                                                    | 0.12        |             | 200            |
| Example 12            | a-1                                                         | 0.6                                     |            |        |                                                                    | 0.12        |             | 250            |
| Example 13            | a-1                                                         |                                         | 0.9        |        |                                                                    |             |             | 150            |
| Example 14            | a-1                                                         |                                         | 1.1        |        |                                                                    |             |             | 150            |
| Example 15            | a-2                                                         | 1.4                                     |            |        |                                                                    | 0.20        |             | 150            |
| Example 16            | a-2                                                         | 1.6                                     |            |        |                                                                    | 0.20        |             | 150            |
| Comparative Example 1 | a-1                                                         | 1.4                                     |            |        |                                                                    |             | 1.00        | 150            |
| Comparative Example 2 | a-1                                                         | 1.4                                     |            |        |                                                                    |             | 1.00        | 150            |
| Comparative Example 3 | a-1                                                         | 0.4                                     |            |        |                                                                    | 0.10        |             | 50             |
| Comparative Example 4 | a-1                                                         | 5.0                                     |            |        |                                                                    | 1.00        |             | 150            |
| Comparative Example 5 | a-1                                                         |                                         |            | 0.1    |                                                                    | 0.10        |             | -              |
| Comparative Example 6 | a-1                                                         |                                         |            |        | 0.1                                                                | 0.10        |             | -              |

[0132]

In Table 1, symbols are as follows:

a-1 represents an acryl-based pressure-sensitive-adhesive composition (a-1) yielded in Production Example 1;

a-2, an acryl-based pressure-sensitive-adhesive composition (a-2) yielded in Production Example 2;

Tinosorb S, 2,4-bis-[[4-(4-ethylhexyloxy)-4-hydroxy}-phenyl]-6-(4-methoxyphenyl)-1,3,5-triazine (manufactured by the BASF);

Tinuvin 928, 2-(2H-benzotriazole-2-yl)-6-(1-methyl-1-phenylethyl)-4-(1,1,3,3-tetramethylbutyl)phenol (manufactured by the BASF);

LA-F70, 2,4,6-tris(2-hydroxy-4-hexyloxy-3-methylphenyl)-1,3,5-triazine (manufactured by Adeka Corp.);

KEMISORB279, 2,2'-methylenebis[6-(benzotriazole-2-yl)-4-tert-octylphenol] (manufactured by Chemipro Kasei Kaisha, Ltd.); and

Irgacure 819, bis(2,4,6-trimethylbenzoyl)-phenylphosphine oxide (trade name, manufactured by BASF Japan Ltd.) having an absorption band at wavelengths of 200 to 450 nm;

Irgacure 651, 2,2-dimethoxy-1,2-diphenylethane-1-one (trade name, manufactured by BASF Japan Ltd.) having an absorption band at wavelengths of 200 to 380 nm; and

Irgacure 184, 1-hydroxy-cyclohexyl-phenyl-ketone

(trade name, manufactured by BASF Japan Ltd.) having an absorption band at wavelengths of 200 to 370 nm.

[0133]

About the resultant pressure-sensitive adhesive sheets, evaluations described below were made.

[0134]

#### <Solubility>

The ultraviolet absorbent used in each of the working examples and the comparative examples was added to an acryl-based pressure-sensitive-adhesive composition shown in Table 1 in an amount of parts described in Table 1 for 100 parts by weight of this composition, and then the solubility of the absorbent was visually observed. The solubility was then evaluated in accordance with the following evaluating criterion:

O: the ultraviolet absorbent is dissolved in the acryl-based pressure-sensitive-adhesive composition without giving any residue thereof.

X: the ultraviolet absorbent is dissolved in the acryl-based pressure-sensitive-adhesive composition to give a residue thereof.

[0135]

#### <Polymerization Rate>

From one of the pressure-sensitive-adhesive sheets yielded in each of the working examples and the comparative

examples, the both release films were peeled off, and then only the pressure-sensitive-adhesive layer was put onto an aluminum petri dish the weight of which had been measured. A measurement was made about the weight of the "aluminum petri dish + pressure-sensitive-adhesive layer". In this way, the weight of the pressure-sensitive-adhesive layer which had not yet been dried was gained. This system was dried at 130°C for 2 hours, and then cooled at ambient temperature for about 20 minutes. A measurement was again made about the weight of the "aluminum petri dish + pressure-sensitive-adhesive layer" to gain the weight of the pressure-sensitive-adhesive layer after the drying. The polymerization rate was then calculated in accordance with the following calculation expression:

[Math. 1]

$$\text{Polymerization rate (\%)} = \frac{(\text{weight of pressure-sensitive-adhesive layer after drying thereof})}{(\text{weight of pressure-sensitive-adhesive layer before drying thereof})} \times 100$$

[0136]

<Gel Fraction>

A piece of about 0.1 g was collected from one of the pressure-sensitive-adhesive sheets yielded in each of the working examples and the comparative examples, and the piece was wrapped with a porous tetrafluoroethylene sheet (trade name: NTF 1122, manufactured by Nitto Denko Corp.) having an average pore size diameter of 0.2 μm.

Thereafter, the resultant was tied with a kite string. At this time, the weight (Z g) of the resultant product was measured. This weight was defined as the before-immersion weight of the product. The before-immersion weight was the total weight of the pressure-sensitive-adhesive layer (the pressure-sensitive-adhesive layer piece collected as described above), the tetrafluoroethylene sheet, and the kite string. The total weight (Y g) of the tetrafluoroethylene sheet and the kite string was also measured. Next, the product (called a "sample"), in which the pressure-sensitive-adhesive layer was wrapped with the tetrafluoroethylene sheet and further tied with the kite string, was put into a 50-mL vessel filled with ethyl acetate. The vessel was then allowed to stand still at 23°C for 7 days. Thereafter, the sample was taken out from the vessel (after the ethyl acetate treatment), and shifted to a cup made of aluminum. The sample was then dried in a drying machine at 130°C for 2 hours to remove ethyl acetate. The weight (X g) of the sample was then measured. This weight was defined as the after-immersion of the sample. In accordance with an expression described below, the gel fraction in the sample was calculated out.

$$\text{Gel fraction (\% by weight)} = (X - Y)/(Z - Y) \times 100$$

[0137]

<Transmittance and b\* Value>

The both release films of any one of the pressure-sensitive-adhesive sheets which were yielded in each of the working examples and the comparative examples were peeled off, and then the pressure-sensitive-adhesive layer was fitted to a measuring tool. The transmittance thereof was measured, using a spectrophotometer (production name: U4100, manufactured by Hitachi High-Technologies Corp.).

[0138]

<Optical Reliability of Single Body of Pressure-Sensitive-Adhesive Layer>

The both release films on both the surfaces of each of some of the pressure-sensitive adhesive sheets yielded in each of the working examples and the comparative examples were peeled off. Glass pieces (trade name: S200200, manufactured by Matsunami Glass Ind., Ltd; thickness: 1.3 mm; size: 45 mm x 50 mm) were bonded, respectively, to both surfaces of the pressure-sensitive-adhesive layer. The resultants were subjected to autoclave treatment (air pressure: 0.5 MPa; temperature: 50°C) for 15 minutes. The resultant samples were put, respectively, into individual reliability conditions 1 to 5 described below. Thereafter, a device U4100 (trade name) manufactured by Hitachi High-Tech Science Corp. was used to measure the transmittance and the hue of each of the samples. The quantity of a change in the transmittance

from the initial value was gained. The reliability of the sample was evaluated in accordance with the following evaluating criterion:

(Various Reliability Conditions)

(Condition 1) 85°C for 500 hours,

(Condition 2) -40°C for 500 hours,

(Condition 3) 60°C and 95% for 500 hours,

(Condition 4) heat shock (HS): "-40°C to 85°C" x 300 cycles, and

(Condition 5) UV radiation for 100 hours; luminance: 500 W/cm<sup>2</sup> at 300 to 700 nm; environment temperature: 60 to 65°C; environment humidity: 50%.

(Evaluation Criterion)

⊙: the transmittance change quantity is 0.2% or less.

○: the transmittance change quantity is more than 0.2%, and 0.7% or less.

△: the transmittance change quantity is more than 0.7%, and 1.0% or less.

×: the transmittance change quantity is more than 1.0%.

[0139]

<Viewability>

Prepared was a polarizing film in which one of front and rear surfaces of a 12-μm-thick polarizer had a TAC film

(25  $\mu\text{m}$ ) subjected to hard coat treatment, and the other surface had an acryl-based film (20  $\mu\text{m}$ ). The respective release films of both surfaces of one of the pressure-sensitive adhesive sheets yielded in each of the working examples and the comparative examples were peeled off, and pressure-sensitive-adhesive layers were bonded, respectively, to the protective films of the polarizing film. Furthermore, glass pieces (trade name: S200200, manufactured by Matsunami Glass Ind., Ltd; thickness: 1.3 mm; size: 45 mm x 50 mm) were bonded, respectively, to the both-surface pressure-sensitive-adhesive layers. The resultants were used as measuring samples. The resultant measuring samples were subjected to autoclave treatment (air pressure: 0.5 MPa; temperature: 50°C) for 15 minutes. An ultraviolet-visible near-infrared spectrophotometer (product name: V7100, manufactured by JASCO Corp.) was used to measure the hue of the sample. The result was evaluated in accordance with the following evaluating criterion:

○: the  $b^*$  value is 1.4 or more, and 3.4 or less.

△: the  $b^*$  value is more than 3.4, and 3.9 or less.

×: the  $b^*$  value is more than 3.9.

[0140]

<Endurance>

The respective release films on both the surfaces of each of some of the pressure-sensitive adhesive sheets

yielded in each of the working examples and the comparative examples were peeled off. Glass pieces (trade name: S200200, manufactured by Matsunami Glass Ind., Ltd; thickness: 1.3 mm; size: 45 mm x 50 mm) were bonded, respectively, to both surfaces of the pressure-sensitive-adhesive layer. The resultants were used as measuring samples. The resultant measuring samples were subjected to autoclave treatment (air pressure: 0.5 MPa; temperature: 50°C) for 15 minutes. The samples were put into respective reliability conditions shown in Table 1 (condition 1: 85°C for 500 hours; condition 2: -40°C for 500 hours; condition 3: 60°C and 95% for 500 hours; condition 4: HS: "-40°C ↔ 85°C" x 300 cycles; and condition 5: UV radiation for 100 hours). Thereafter, a loupe or an electron microscope was used to measure the evaluating samples. The samples were each evaluated in accordance with the following evaluating criterion:

○: no peel or exfoliation was caused from an edge of the sample, and no air bubbles are generated.

×: a peel or exfoliation was caused or air bubbles are generated.

[0141]

<UV Resistance (Protecting Function of Polarizing Film)>

Prepared was a polarizing film in which one of front and rear surfaces of a 12-μm-thick polarizer was protected

with a TAC film (25  $\mu\text{m}$ ) subjected to hard coat treatment, and the other surface of the polarizer was protected with an acryl-based film (20  $\mu\text{m}$ ). The respective release films of both surfaces of one of the pressure-sensitive adhesive sheets yielded in each of the working examples and the comparative examples were peeled off, and then pressure-sensitive-adhesive layers were bonded, respectively, to the protective films of the polarizing film. Furthermore, glass pieces (trade name: S200200, manufactured by Matsunami Glass Ind., Ltd; thickness: 1.3 mm; size: 45 mm x 50 mm) were bonded, respectively, to the both-surface pressure-sensitive-adhesive layers. The resultant was used as a measuring sample. The resultant measuring sample was subjected to autoclave treatment (air pressure: 0.5 MPa; temperature: 50°C) for 15 minutes. Thereafter, the sample was put into the following UV-radiating conditions: an illuminance of 500 W/cm<sup>2</sup> (at 300 to 700 nm), an environment temperature of 60 to 65°C, and an environment humidity of 50%. An ultraviolet-visible near-infrared spectrophotometer (product name: V7100, manufactured by JASCO Corp.) was then used to measure the sample. In this way, the quantity of a change in the transmittance of the sample was gained. The reliability of the sample was evaluated in accordance with the following evaluating criterion:

⊙: the transmittance change quantity is 1.0% or less.

○: the transmittance change quantity is more than 1.0%, and 2.0% or less.

△: the transmittance change quantity is more than 2.0%, and 3.0% or less.

×: the transmittance change quantity is more than 3.0%.

[Table 2]

|                          | Physical properties |                               |                        |                                |                                |             | Optical reliability<br>(transmittance change)<br>for simple body of<br>pressure-sensitive<br>adhesive |             |                          |    | Viewability | Endurance     |             |                          |    | UV<br>resistance<br>(protecting<br>function of<br>polarizing<br>plate) |
|--------------------------|---------------------|-------------------------------|------------------------|--------------------------------|--------------------------------|-------------|-------------------------------------------------------------------------------------------------------|-------------|--------------------------|----|-------------|---------------|-------------|--------------------------|----|------------------------------------------------------------------------|
|                          | Solubility          | Polymerization<br>rate<br>(%) | Gel<br>fraction<br>(%) | Transmittance<br>(%) at 400 nm | Transmittance<br>(%) at 380 nm | b*<br>value | 85°C<br>-40°C                                                                                         | 60°C<br>95% | HS<br>-40°C<br>↔<br>85°C | UV |             | 85°C<br>-40°C | 60°C<br>95% | HS<br>-40°C<br>↔<br>85°C | UV |                                                                        |
| Example 1                | ○                   | 98.6                          | 86.0                   | 62.5                           | 0.2                            | 0.78        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 2                | ○                   | 98.6                          | 86.4                   | 68.9                           | 1.3                            | 0.69        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 3                | ○                   | 98.5                          | 87.0                   | 77.4                           | 4.3                            | 0.46        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 4                | ○                   | 98.9                          | 89.0                   | 42.3                           | 0.0                            | 1.82        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | △           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 5                | ○                   | 98.4                          | 88.5                   | 32.3                           | 0.0                            | 2.17        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | △           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 6                | ○                   | 97.7                          | 85.0                   | 87.5                           | 36.9                           | 0.25        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | △                                                                      |
| Example 7                | ○                   | 97.8                          | 85.2                   | 84.5                           | 20.9                           | 0.31        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | △                                                                      |
| Example 8                | ○                   | 98.3                          | 85.3                   | 81.6                           | 11.9                           | 0.37        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ○                                                                      |
| Example 9                | ○                   | 98.8                          | 85.8                   | 77.8                           | 6.5                            | 0.55        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 10               | ○                   | 98.6                          | 85.0                   | 73.5                           | 2.4                            | 0.47        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 11               | ○                   | 98.5                          | 85.8                   | 71.0                           | 1.7                            | 0.64        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 12               | ○                   | 98.4                          | 86.0                   | 65.7                           | 0.0                            | 0.73        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 13               | ○                   | 98.2                          | 81.2                   | 73.4                           | 5.4                            | 0.63        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 14               | ○                   | 98.2                          | 79.9                   | 67.4                           | 2.6                            | 0.86        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 15               | ○                   | 96.2                          | 90.3                   | 64.0                           | 0.2                            | 0.78        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Example 16               | ○                   | 91.7                          | 83.6                   | 61.5                           | 0.0                            | 0.75        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Comparative<br>Example 1 | ○                   | 74.6                          | 60.0                   | 63.0                           | 0.0                            | 0.77        | ○                                                                                                     | ○           | ○                        | ○  | ○           | ×             | ×           | ×                        | ×  | -                                                                      |
| Comparative<br>Example 2 | ○                   | 35.0                          | 48.0                   | 63.0                           | 0.0                            | 0.72        | ○                                                                                                     | ○           | ○                        | ○  | ○           | ×             | ×           | ×                        | ×  | -                                                                      |
| Comparative<br>Example 3 | ○                   | 97.8                          | 85.0                   | 90.0                           | 40.5                           | 0.20        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ○           | ○             | ○           | ○                        | ○  | ×                                                                      |
| Comparative<br>Example 4 | ○                   | 98.5                          | 86.5                   | 20.0                           | 0.0                            | 3.12        | ⊙                                                                                                     | ⊙           | ⊙                        | ⊙  | ×           | ○             | ○           | ○                        | ○  | ⊙                                                                      |
| Comparative<br>Example 5 | ×                   | -                             | -                      | -                              | -                              | -           | -                                                                                                     | -           | -                        | -  | -           | -             | -           | -                        | -  | -                                                                      |
| Comparative<br>Example 6 | ×                   | -                             | -                      | -                              | -                              | -           | -                                                                                                     | -           | -                        | -  | -           | -             | -           | -                        | -  | -                                                                      |

DESCRIPTION OF REFERENCE SIGNS

[0143]

1        Cover Glass or Cover Plastic

2a to 2c    Pressure-Sensitive-Adhesive Layers

3a, 3b       Protective Films

4        Polarizer

5        Polarizing Film

6        Liquid Crystal Display Device (LCD) or Organic

EL Display Device (OLED)

7        Sensor Layer

## CLAIMS

1. An ultraviolet-curable acryl-based pressure-sensitive-adhesive composition for forming a pressure-sensitive-adhesive layer having a transmission  $b^*$  value of 3.0 or less positioned between a cover glass or cover plastic and a polarizing film in an image display device,

the polarizing film being a single-sided protected polarizing film having a polarizer and a transparent protective film on one surface of the polarizer,

the pressure-sensitive-adhesive composition comprising a monomer component comprising an alkyl (meth)acrylate and hydroxyl group-containing monomer which is a monofunctional monomer component as a copolymerizable monomer other than the alkyl(meth)acrylate and/or a partially polymerized product made from the monomer component, an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more, and

a proportion of the alkyl (meth)acrylate is 40% or more by weight of the whole of one or more monofunctional monomer component from which a (meth)acryl-based polymer is made, and a proportion of the hydroxyl-group-containing monomer is 30% or less by weight of the whole of the monofunctional monomer component, from which the

(meth)acryl-based polymer is made, and

wherein the photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more is present at an amount of 0.02 part by weight to an amount less than 0.2 part by weight for 100 parts by weight of the whole of the monofunctional monomer component, from which the (meth)acryl-based polymer is made.

2. The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition according to claim 1, wherein the ultraviolet absorbent is at least one ultraviolet absorbent selected from the group consisting of triazine-based ultraviolet absorbent having, in a single molecule, two or less hydroxyl groups, and benzotriazole-based ultraviolet absorbent having, in a single molecule, one benzotriazole skeleton.

3. The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition according to claim 1 or 2, wherein the photopolymerization initiator (A) is smaller in addition amount than the ultraviolet absorbent.

4. The ultraviolet-curable acryl-based pressure-sensitive-adhesive composition according to any one of claims 1 to 3, further comprising a photopolymerization

initiator (B) having an absorption band at wavelengths less than 400 nm.

5. An ultraviolet-curable acryl-based pressure-sensitive-adhesive layer, which is a pressure-sensitive-adhesive layer positioned between a cover glass or cover plastic, and a polarizing film in an image display device, and

which is formed by radiating an ultraviolet ray to the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition according to any one of claims 1 to 4 to photopolymerize the monomer component in the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition.

6. A pressure-sensitive-adhesive layer-attached polarizing film, comprising a polarizing film, and the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer according to claim 5 provided on at least one surface of the polarizing film.

7. A method for producing ultraviolet-curable acryl-based pressure-sensitive adhesive layer formed from the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition according to claim 4,

the method comprising:

the step of radiating a composition comprising a monomer component comprising an alkyl (meth)acrylate, and the photopolymerization initiator (B) to produce a partially polymerized product made from the monomer component;

the step of adding an ultraviolet absorbent, and a photopolymerization initiator (A) having an absorption band at wavelengths of 400 nm or more to the partially polymerized product made from the monomer component to produce an ultraviolet-curable acryl-based pressure-sensitive-adhesive composition; and

the step of applying the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition to at least one surface of a substrate, and radiating an ultraviolet ray to the ultraviolet-curable acryl-based pressure-sensitive-adhesive composition.

8. An image display device, having at least a cover glass or cover plastic, and a polarizing film,

the display device having the ultraviolet-curable acryl-based pressure-sensitive-adhesive layer according to claim 5 positioned between the cover glass or cover plastic and the polarizing film.