

DESCRIPTION

RESIN COMPOSITION FOR OPTICAL COMPONENT, AND OPTICAL
COMPONENT PRODUCED BY USING THE RESIN COMPOSITION

5 TECHNICAL FIELD

[0001] The present invention relates to a photocurable
resin composition (transparent resin for optical
applications) which is advantageous as an optical
material for various optical components such as an
10 optical lens and a light converging/diverging lens and
an optical component bonding agent which are required
to be highly heat-resistant and highly transparent for
transmission of optical signals with a lower loss. The
invention further relates to an optical component
15 produced by using the resin composition.

BACKGROUND ART

[0002] In recent optical components such as imaging
devices for use in mobile phones and digital cameras,
imaging optical lenses are mounted. Optical glass
20 materials and transparent plastic materials are
generally used as lens materials. Particularly, with
recent increased popularity of mobile phones having an
imaging function, there is a need for producing the
optical lenses at lower costs. Therefore, optically
25 transparent polyolefin materials that permit easy

designing of the lenses are mainly used as the plastic lens materials. In general, the imaging device is mounted on a printed board by a pin insertion process using a socket or by first mounting an imaging element
5 on the printed board by a solder reflow process and then attaching a lens unit to the imaging element. For mass production at lower costs, it is strongly desirable to mount the imaging device per se on the printed board by the solder reflow process.

10 [0003] Where the imaging device per se is to be mounted on the printed board by the solder reflow process, however, the plastic lens is subjected to a high temperature environment at a temperature higher than a softening point thereof. This leads to a problem
15 associated with the softening and the dimensional deformation of the plastic lens. To solve this problem, it is contemplated to use a resin composition mainly containing a highly heat-resistant epoxy resin as a material for the optical lens and other optical
20 components. An inprint production method using a heat-resistant photocurable resin, for example, is now put into practical application. In the inprint method, a shaping mold is pressed against a resin material to form a specific minute pattern or a textured product
25 (e.g., PTL 1).

[0004] With recent trend toward reduction in the thickness of the optical lens and increase in the resolution, there is a demand for a resin material having a higher refractive index. In order to increase the refractive index of the resin composition, it is necessary to use a raw material having a higher refractive index. For example, a material containing a benzene ring in its skeleton is generally known to have a higher refractive index, and is useful for increasing the refractive index of the resin composition. However, the benzene ring-containing material is known to have a lower transparency due to the light absorption of the aromatic ring and suffer from thermal discoloration. In general, the higher refractive index material has a rigid structure and, hence, is mostly solid at an ordinary temperature with a higher melting point. For example, a fluorene skeleton-containing epoxy resin, which is known as a higher refractive index material and studied from various aspects, is solid at the ordinary temperature and has a higher viscosity in a melted state. Therefore, a resin composition containing the fluorene skeleton-containing epoxy resin in a greater amount to be imparted with a higher refractive index is liable to have a higher viscosity and hence poorer handlability.

Similarly, an epoxy resin containing a biphenyl skeleton having a glycidyl group at a p-position for general use is solid at the ordinary temperature with a higher melting point. Therefore, a composition
5 containing such an epoxy resin is liable to have a higher viscosity and hence poorer handlability. To cope with this, a solvent or a liquid epoxy resin is added to the resin composition (PTL 2 and PTL 3).

RELATED ART DOCUMENT

10 PATENT DOCUMENT

[0005] PTL 1: JP3926380

PTL 2: JP-A-2012-129010

PTL 3: JP-A-2011-225773

SUMMARY OF INVENTION

15 [0006] In the conventional art, the higher refractive index resin problematically has a higher viscosity and hence poorer handlability, and fails to have a higher transparency.

[0007] In view of the foregoing, it is an object of the
20 present invention to provide an optical component resin composition which has excellent handlability, a higher transparency and excellent heat resistance and is advantageous as an optical component material with a higher refractive index after curing, and to provide
25 an optical component produced by using the resin

composition.

[0008] According to a first aspect of the present invention to achieve the above object, there is provided an optical component resin composition which has a
5 viscosity of 0.1 to 20 Pa·s at 25°C, and has a refractive index of not less than 1.57 and an Abbe number of 20 to 40 in a cured state.

[0009] According to a second aspect of the present invention, there is provided an optical component made
10 of a cured product of the optical component resin composition of the first aspect.

[0010] The inventor of the present invention conducted intensive studies to provide an optical component resin composition having a higher refractive index and an
15 excellent heat resistance. As a result, the inventor focused on the viscosity of the resin composition in an uncured state and the refractive index and the Abbe number of the resin composition in a cured state, and conducted an experiment to find optimum ranges of these
20 factors. As a result, the inventor found that, where the optical component resin composition has a viscosity of 0.1 to 20 Pa·s at 25°C and the cured product of the optical component has a refractive index of not less than 1.57 and an Abbe number of 20 to 40, the intended
25 object can be achieved. Thus, the inventor attained

the present invention. Further, the inventive optical component resin composition can be used on a solvent-free basis. Therefore, the cured product of the resin composition is free from voids which may otherwise occur in the product during the molding, and is advantageous for use as an optical component.

[0011] The inventive optical component resin composition thus has a viscosity of 0.1 to 20 Pa·s at 25°C and, hence, is excellent in handlability. As described above, the inventive optical component resin composition is imparted with the aforementioned viscosity without the use of the organic solvent and, therefore, is free from the problem associated with the voids which may otherwise occur in the cured product of the resin composition when the organic solvent is evaporated during a photo-curing/molding process.

Since the inventive optical component resin composition can be photo-cured on a transparent substrate such as a glass plate, it is possible to produce a high quality hybrid lens by combining the cured product of the resin composition with the transparent substrate. Further, the cured product of the optical component resin composition has a higher refractive index and a smaller Abbe number and, therefore, is highly transparent and substantially free from thermal discoloration. This

improves the optical design flexibility of a thin film of the resin composition. Further, the optical component resin composition may be used alone to be cured, for example, for production of a highly heat-resistant plastic lens. Thus, a highly reliable optical component can be produced by using the inventive optical component resin composition as a lens formation material or other optical component formation material or as a photocurable adhesive agent for bonding an optical component. Therefore, the inventive optical component resin composition is useful.

[0012] Where the inventive optical component resin composition contains an epoxy resin represented by a general formula (1) shown below, the epoxy resin is expected to serve as a viscosity controlling component to impart the resin composition with a lower viscosity while imparting the cured product of the resin composition with a higher refractive index.

[0013] Where the inventive optical component resin composition further contains a fluorene epoxy resin having a refractive index of not less than 1.60, the resin composition has a further higher refractive index.

DESCRIPTION OF EMBODIMENTS

[0014] Next, an embodiment of the present invention

will be described in detail. However, it should be understood that the present invention be not limited to this embodiment.

[0015] <<Resin Composition for Optical Component>>

5 An optical component resin composition according to the present invention (hereinafter sometimes referred to simply as "resin composition") has a viscosity of 0.1 to 20 Pa·s at 25°C in an uncured state, and has a refractive index of not less than 1.57
10 and an Abbe number of 20 to 40 in a cured state. The viscosity and other physical properties of the resin composition will be described later.

[0016] The inventive optical component resin composition having such physical properties is prepared,
15 for example, by using epoxy resins, an epoxy resin curing agent and other additives (oxetane resin and the like) in combination. As described above, the inventive optical component resin composition can be used on a solvent-free basis.

20 [0017] The respective ingredients will be described in turn below.

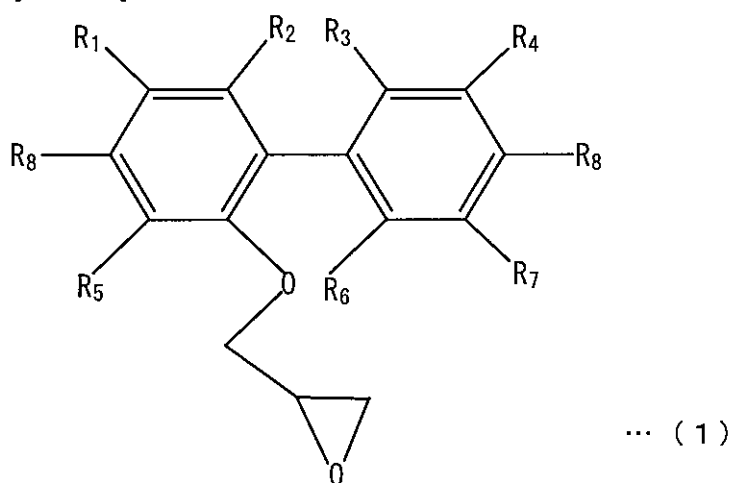
[0018] <Epoxy Resins>

The epoxy resins may be properly selected from various epoxy resins in consideration of the desired
25 viscosity, refractive index and photo-curability. For

a higher refractive index, epoxy resins having a fluorene skeleton, a biphenyl skeleton or a naphthalene skeleton, bisphenol epoxy resins and the like are usable.

5 [0019] Particularly, preferred examples of an epoxy resin having a higher refractive index and expected to serve as a viscosity controlling component for reducing the viscosity include epoxy resins having a biphenyl skeleton having a glycidyl group at the o-position of
10 the benzene ring thereof. A specific example of such an epoxy resin is an epoxy resin represented by the following general formula (1). These may be used alone or in combination.

[0020]



15

wherein R₁ to R₇, which may be the same or different, are each C_nH_{2n+1} (wherein n is a positive number of 1 to 5), H, a monovalent aromatic ring, an aromatic ring
20 connected via a carbon atom or an oxygen atom, an

alcoholic hydroxyl group or a glycidyl ether group, and R_8 is H.

[0021] In the formula (1), R_1 to R_7 are particularly preferably all H (hydrogen atom).

5 [0022] The epoxy resin represented by the above general formula (1) preferably has an epoxy equivalent of 100 to 500.

[0023] The epoxy resin represented by the above general formula (1) preferably has a refractive index of not
10 less than 1.57 and a melting point of not higher than 90°C, particularly preferably a refractive index of not less than 1.58 and a melting point of not higher than 85°C.

[0024] A specific example of the epoxy resin
15 represented by the above general formula (1) is OPP-G available from Sanko Co., Ltd.

[0025] The proportion of the epoxy resin represented by the above general formula (1) is preferably 5 to 75 wt%, particularly preferably 10 to 70 wt%, based on the
20 weight of the overall resin component of the optical component resin composition. If the proportion of this epoxy resin is excessively small, it will be difficult to impart the resin composition with a lower viscosity and a higher refractive index as intended. If the
25 proportion of this epoxy resin is excessively great,

the resin composition is liable to be more brittle.

[0026] For a higher refractive index, the above epoxy resin is preferably used in combination with a fluorene epoxy resin. The fluorene epoxy resin may be properly
5 selected from various fluorene epoxy resins having a fluorene skeleton in consideration of the desired viscosity, refractive index and photocurability.

Specific examples of the fluorene epoxy resin include PG-100 and EG-200 available from Osaka Gas Chemicals
10 Co., Ltd. These may be used alone or in combination.

[0027] The proportion of the fluorene epoxy resin is preferably less than 60 wt%, particularly preferably less than 50 wt%, based on the weight of the overall resin component of the optical component resin
15 composition. If the proportion of the fluorene epoxy resin is excessively great, the resin composition is liable to have a higher viscosity and hence poorer handlability.

[0028] The fluorene epoxy resin preferably has a
20 refractive index of not less than 1.60, particularly preferably not less than 1.62.

[0029] For improvement of the handlability and the reliability, the optical component resin composition may additionally contain a monofunctional or
25 difunctional epoxy resin other than the epoxy resin

represented by the above general formula (1) and the fluorene epoxy resin in a proportion such as to impart the resin composition with the desired refractive index. Examples of the additional epoxy resin include an alicyclic epoxy resin and a hydrogenated bisphenol epoxy resin. Particularly, for a higher refractive index, a bisphenol-A epoxy resin and a bisphenol-F epoxy resin are preferably used.

[0030] <Epoxy Resin Curing Agent>

A curing agent, such as a photopolymerization initiator, a heat-acid generator or an imidazole curing catalyst, that allows an epoxy resin polymerization reaction to proceed, or a curing assisting agent is used as the epoxy resin curing agent according to the use purpose of the resin composition. Examples of the photopolymerization initiator include onium salts, such as containing an antimony or phosphorus anion moiety and a sulfonium, iodonium or phosphonium cation moiety, that are capable of initiating cationic polymerization. Specific examples of the photopolymerization initiator include aromatic sulfonium salts, aromatic iodonium salts, aromatic phosphonium salts and aromatic sulfoxonium salts, among which the aromatic sulfonium salts are preferred for photocurability.

[0031] The proportion of the epoxy resin curing agent

to be used as the photopolymerization initiator, for example, is preferably set to 0.05 to 3 parts by weight, particularly preferably 0.05 to 2 parts by weight, based on 100 parts by weight of the resin component of the optical component resin composition. If the proportion of the epoxy resin curing agent is excessively small, the resin composition is liable to have poorer curability. If the proportion of the epoxy resin curing agent is excessively great, the resin composition is improved in curability, but the cured product of the resin composition is liable to have poorer transparency.

[0032] <Other Additives>

For improvement of the handlability and the curability, an oxetane resin may be added to the inventive optical component resin composition. Usable as the oxetane compound are oxetane compounds having one or more oxetane rings in each molecule thereof. Examples of the oxetane compound include

1,4-bis{[(3-ethyl-3-oxetanyl)methoxy)methyl}benzene,
 di[2-(3-oxetanyl)butyl]ether,
 3-ethyl-3-hydroxymethyloxetane, xylylenebisoxetane,
 3-ethyl-3-{[(3-ethyloxetan-3-yl)methoxy)methyl}oxetane,
 3-ethyl-3-(phenoxymethyl)oxetane,
 4,4'-bis[(3-ethyl-3-oxetanyl)methoxymethyl]biphenyl,

1,4-bis[(3-ethyloxetan-3-yl)methoxy]benzene,
 1,3-bis[(3-ethyloxetan-3-yl)methoxy]benzene,
 1,2-bis[(3-ethyloxetan-3-yl)methoxy]benzene,
 4,4'-bis[(3-ethyloxetan-3-yl)methoxy]biphenyl,
 5 2,2'-bis[(3-ethyl-3-oxetanyl)methoxy]biphenyl,
 3,3',5,5'-tetramethyl-[4,4'-bis(3-ethyloxetan-3-yl)
 methoxy]biphenyl,
 2,7-bis[(3-ethyloxetan-3-yl)methoxy]naphthalene,
 1,6-bis[(3-ethyloxetan-3-yl)methoxy]-2,2,3,3,4,4,5,5-
 10 octafluorohexane,
 3(4),8(9)-bis[(1-ethyl-3-oxetanyl)methoxy]methyl-tricyclo
 [5.2.1.2.6]decane,
 1,2-bis{[2-(1-ethyl-3-oxetanyl)methoxy]ethylthio}ethane,
 4,4'-bis[(1-ethyl-3-oxetanyl)methyl]thiodibenzene
 15 thioether,
 2,3-bis[(3-ethyloxetan-3-yl)methoxymethyl]norbornane,
 2-ethyl-2-[(3-ethyloxetan-3-yl)methoxymethyl]-1,3-o-
 bis[(1-ethyl-3-oxetanyl)methyl]-propane-1,3-diol,
 2,2-dimethyl-1,3-o-bis[(3-ethyloxetan-3-yl)methyl]-
 20 propane-1,3-diol,
 2-butyl-2-ethyl-1,3-o-bis[(3-ethyloxetan-3-yl)methyl]-
 propane-1,3-diol,
 1,4-o-bis[(3-ethyloxetan-3-yl)methyl]-butane-1,4-diol,
 and 2,4,6-o-tris[(3-ethyloxetan-3-yl)methyl]cyanurate.
 25 These may be used alone or in combination.

[0033] The proportion of the oxetane compound is preferably set to 5 to 40 wt% based on the weight of the overall resin component of the optical component resin composition. If the proportion of the oxetane compound is excessively great, it will be difficult to provide a higher refractive index as desired.

[0034] The inventive optical component resin composition may further contain a photo-sensitizer such as anthracene and an acid proliferating agent for improvement of the curability. Where a cured product of the resin composition is to be formed on a substrate such as a glass substrate, a silane or titanium coupling agent may be added to the resin composition to increase the adhesiveness of the resin composition to the

substrate. As required, the resin composition may further contain additives such as a plasticizing agent (e.g., a synthetic rubber and a silicone compound), an antioxidant, a defoaming agent, a pigment, a dye and an inorganic filler. Addition of an organic solvent or the like for the improvement of the handlability is not preferred, because voids are liable to occur in the cured product during the molding or the characteristic properties are liable to be impaired. Therefore, the resin composition is preferably designed on the solvent-free basis.

[0035] The inventive optical component resin composition may be prepared by heat-melting and mixing the epoxy resin component including the epoxy resin represented by the above general formula (1), the
5 fluorene epoxy resin and the like, the epoxy resin curing agent and, as required, any of the aforementioned additives (the oxetane compound and the like) in predetermined proportions.

[0036] The inventive optical component resin
10 composition thus prepared satisfies all the following physical property requirements (1) to (3), which are the features of the present invention.

[0037] (1) Viscosity

The inventive optical component resin
15 composition has a viscosity of 0.1 to 20 Pa·s, preferably 0.1 to 18 Pa·s at 25°C. If the viscosity of the resin composition is excessively low, it will be difficult to control the solution amount of the resin composition to be applied dropwise, for example, by an inkjet method.
20 If the viscosity of the resin composition is excessively high, the resin composition is liable to be poorer in handlability.

[0038] The viscosity of the optical component resin composition is measured at a temperature of 25°C, for
25 example, with the use of a standard rotor (1°34' × R24)

by means of an E-80 Model viscometer (RE-80U) available from Toki Sangyo Co., Ltd.

[0039] (2) Refractive Index

The cured product of the inventive optical
5 component resin composition has a refractive index of not less than 1.57, preferably 1.59 to 1.64. If the refractive index of the cured product is excessively low, an optical lens to be formed from the resin composition for a mobile device or the like will have
10 a greater thickness, making it difficult to reduce the height of a camera module.

[0040] For measurement of the refractive index of the cured product of the optical component resin composition, a molded product is prepared by pouring
15 the resin composition (liquid resin) in a transparent shaping mold having a predetermined size (e.g., $1 \times 1.5 \times 0.5$ cm), curing the resin composition by irradiation with ultraviolet (UV) radiation (e.g., at $10,000 \text{ mJ/cm}^2$), demolding the resulting cured product from the mold,
20 and heat-treating the cured product under predetermined conditions (e.g., at 150°C for 1 hour). Then, the surface of the resulting molded product is polished by means of a grinder, and the refractive index of the molded product was measured at 25°C environment by means
25 of a refractometer (available from Atago Co., Ltd.)

[0041] (3) Abbe Number

The cured product of the inventive optical component resin composition has an Abbe number of 20 to 40, preferably 20 to 35. If the Abbe number of the cured product is excessively small, the resulting cured product is highly dependent upon the wavelength and, therefore, is liable to suffer from color blurring or the like depending on the use purpose.

[0042] In the present invention, the Abbe number indicates a so-called reciprocal dispersion of an optical component (cure product) such as the optical lens. The refractive index of the cured product (test piece) of the optical component resin composition is measured in conformity with JIS Z8120 at $25 \pm 10^\circ\text{C}$ by means of an Abbe refractometer, and the Abbe number is calculated from the following mathematical expression (x):

$$\text{Abbe number} = \frac{[\text{Refractive index at 589 nm}] - 1}{[\text{Refractive index at 486 nm}] - [\text{Refractive index at 656 nm}]} \dots (x)$$

[0043] After the surface of the cured product (optical component or the like) is polished by means of a grinder, the Abbe number of the cured product is measured by means of a refractometer (available from Atago Co., Ltd.)

[0044] The inventive optical component resin composition preferably has a viscosity of 0.05 to 5.0

Pa·s, more preferably 0.05 to 4.5 Pa·s at 40°C. If the viscosity of the resin composition is excessively low, it will be difficult to control the liquid amount, for example, in application of the resin composition by an inkjet method. If the viscosity of the resin composition is excessively high, the resin composition is liable to be poorer in handlability.

[0045] The cured product of the inventive optical component resin composition preferably has a transmittance of not less than 80 %, more preferably not less than 83 %, at a wavelength of 400 nm. If the transmittance of the resin composition is excessively low, the resin composition is liable to be poorer in transparency.

[0046] The inventive optical component resin composition is used, for example, in the following manner. The resin composition is applied on a transparent substrate such as of glass, and a predetermined shaping mold is pressed against the resin composition to be thereby filled with the resin composition. In turn, the resin composition is irradiated with light to be thereby cured, and then the shaping mold is removed. Thus, a cured product (molded product) of the resin composition combined with the transparent substrate is provided. Alternatively, the

resin composition may be poured in a light-transmissive transparent mold, and photo-cured. A hybrid lens, for example, is produced from the inventive optical component resin composition by the aforementioned production method. The inventive optical component resin composition may be cured alone in the shaping mold to provide an optical component such as an optical lens. The molded product (cured product) thus obtained may be demolded from the shaping mold and further heat-treated at a predetermined temperature as required. The heat treatment enhances the heat stability of the cured product. Particularly in the case of the cured product combined with the transparent substrate, the heat treatment enhances the adhesion between the substrate and the cured resin product.

[0047] For example, a UV lamp, a single-band lamp of a predetermined wavelength or the like may be used as a device for the light irradiation. Exemplary light sources include a low pressure mercury lamp, a high pressure mercury lamp, an ultrahigh pressure mercury lamp and a xenon lamp. The irradiation dose is preferably 2000 to 200000 mJ/cm². If the irradiation dose is less than the aforementioned range, it will be impossible to provide an intended cured product configuration on the substrate due to insufficient

curing. If the irradiation dose is greater than the
aforementioned range, on the other hand,
photo-degradation is liable to occur due to excessive
light irradiation, impairing the transparency by
5 discoloration due to the subsequent heat treatment and
the like. Conditions for the heat treatment to be
performed after the light irradiation are preferably
a treatment temperature of 80°C to 170°C and a treatment
period of about 1 hour.

10 [0048] The inventive optical component resin
composition may be formed into a sheet without the use
of the shaping mold.

[0049] The inventive optical component resin
composition prepared in the aforementioned manner is
15 effective in that the cured product thereof is less
susceptible to thermal discoloration during a solder
reflow process and is imparted with stable mechanical
properties against thermal stress. Therefore, the
inventive cured product can be advantageously used when
20 a component incorporating the inventive cured product
is mounted by the solder reflow process in a single
process step.

[0050] The inventive optical component resin
composition is usable as a material (optical component
25 material) for an optical lens and other optical

component, which are to be produced by the
aforementioned production method. Further, the
inventive optical component resin composition is usable
as a photo-curable adhesive agent for bonding an optical
5 waveguide and other optical component.

EXAMPLES

[0051] Next, the present invention will be described
by way of examples thereof. However, it should be
understood that the present invention be not limited
10 to these examples. In the examples, the term "part(s)"
means "part(s) by weight" unless otherwise specified.

[0052] Prior to preparation of resin compositions of
Examples, the following epoxy resins, epoxy resin
curing agent and other additives were prepared.

15 [0053] <Epoxy Resins>

(a-1) An epoxy resin (having a refractive index of 1.59,
a melting point of 50°C and an epoxy equivalent of 226
g/eq) represented by the above formula (1), wherein R₁
to R₈ are all H.

20 (a-2) An epoxy resin (having a refractive index of 1.62,
a melting point of 70°C and an epoxy equivalent of 165
g/eq) represented by the above formula (1), wherein R₃
is a phenyl group, R₈ is -O-Gly (Gly: glycidyl group),
and R₁ to R₇ excluding R₃ are H.

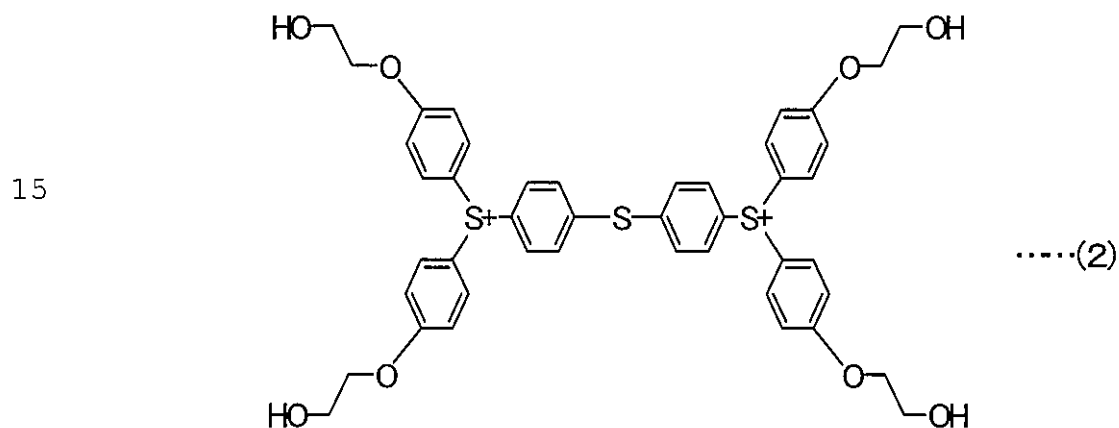
25 (a-3) An epoxy resin (having a refractive index of

1.585, a melting point of 40°C and an epoxy equivalent of 113 g/eq) represented by the above formula (1), wherein R₃ is -O-Gly (Gly: glycidyl group) and R₁ to R₈ excluding R₃ are H.

5 [0054] <Epoxy Resin Curing Agent>

(b-1) A triaryl sulfonium salt photopolymerization initiator (photoacid generator) containing an anion moiety of Sb₆⁻ and a cation moiety represented by the following structural formula (2) (in the form of 50 wt%
10 propylene carbonate solution).

[0055]



20 [0056] <Other Additives>

(c-1) A bisphenol-A epoxy resin (which was solid (at 25°C), and had an epoxy equivalent of 175 g/eq, a softening point of 45°C and a refractive index of 1.57)

(c-2) A fluorene epoxy resin (having an epoxy
25 equivalent of 259 g/eq and a refractive index of 1.64)

(c-3)

3-ethyl-3-([(3-ethyloxetan-3-yl)methoxy]methyl)oxetane

(c-4) A silane coupling agent

3-glycidoxypropylmethyldiethoxysilane

5 (c-5)

9,10-dihydro-9-oxa-10-phosphaphenanthrene-10-oxide

(c-6) A fluorene epoxy resin (having an epoxy equivalent of 311 g/eq and a refractive index of 1.68)

(YX4000) A biphenyl epoxy resin (available from
10 Mitsubishi Chemical Corporation)
(YX4000H) A biphenyl epoxy resin (available from
Mitsubishi Chemical Corporation)

[0057] [Examples 1 to 8 and Comparative Examples 1 to
5]

15 Optical component resin compositions were
prepared by blending the aforementioned ingredients in
proportions as shown below in Tables 1 and 2, and then
heat-melting and mixing the blended ingredients.

[0058] The optical component resin compositions of
20 Examples and Comparative Examples thus prepared were
evaluated for characteristic properties based on the
following criteria. The results are also shown below
in Tables 1 and 2.

[0059] [Refractive Index]

25 The optical component resin compositions

(liquid resins) were each poured in a transparent shaping mold having a size of $1 \times 1.5 \times 0.5$ cm, and irradiated with ultraviolet (UV) radiation at 10,000 mJ/cm² to be thereby cured. Then, the resulting product was demolded from the mold, and heat-treated at 150°C for 1 hour. The surface of the resulting molded product was polished by means of a grinder, and then the refractive index of the molded product was measured at 25°C environment by means of a refractometer (available from Atago Co., Ltd.) As a result, an optical component resin composition having a refractive index of less than 1.57 was rated as unacceptable (x), and an optical component resin composition having a refractive index of not less than 1.57 was rated as acceptable (o).

[0060] [Abbe Number]

With the use of samples formed for the measurement of the refractive index, the Abbe number of each of the optical component resin compositions was calculated from the above mathematical expression (x) based on measurement performed in an Abbe measurement mode by the same device (available from Atago Co., Ltd.) as used for the measurement of the refractive index. As a result, an optical component resin composition having an Abbe number of less than 20 or greater than 40 was rated as unacceptable (x), and an optical

component resin composition having an Abbe number of not less than 20 and not greater than 40 was rated as acceptable (○).

[0061] [Viscosity at 25°C]

5 The viscosity of each of the optical component resin compositions was measured at 25°C environment with the use of a standard rotor (1°34' × R24) by means of an E-80 Model viscometer (RE-80U) available from Toki Sangyo Co., Ltd. As a result, an optical component
10 resin composition having a viscosity of lower than 0.1 Pa·s or higher than 20 Pa·s was rated as unacceptable (×), and an optical component resin composition having a viscosity of not lower than 0.1 Pa·s and not higher than 20 Pa·s was rated as acceptable (○).

15 [0062] [Viscosity at 40°C]

 The viscosity of each of the optical component resin compositions was measured at 40°C environment with the use of a standard rotor (1°34' × R24) by means of an E-80 Model viscometer (RE-80U) available from Toki
20 Sangyo Co., Ltd. As a result, an optical component resin composition having a viscosity of lower than 0.05 Pa·s or higher than 5 Pa·s was rated as unacceptable (×), and an optical component resin composition having a viscosity of not lower than 0.05 Pa·s and not higher than
25 5 Pa·s was rated as acceptable (○).

[0063] [Thermal Discoloration Resistance (a)
(Transparency)]

The optical component resin compositions were each formed into a film having a thickness of 300 μm on a PET film (DIAFOIL MRF-50 available from Mitsubishi Chemical Polyester Film Company) treated with a silicone release agent. The film was primarily cured by irradiation with light (at an irradiation dose of 10,000 mJ/cm^2), and then the film was heat-treated at 150°C for 1 hour. Thus, a cured product (test piece) was produced. The light transmittance of the test piece was measured at a wavelength of 400 nm by means of a spectrophotometer (available from JASCO Corporation), and checked. As a result, a test piece having a light transmittance of lower than 70 % was rated as unacceptable (x), and a test piece having a light transmittance of not lower than 70 % and lower than 80 % was rated as acceptable (Δ). Further, a test piece having a light transmittance of not lower than 80 % was rated as excellent (o).

[0064] [Thermal Discoloration Resistance (b)
(Transparency)]

The optical component resin compositions were each formed into a film having a thickness of 300 μm on a PET film (DIAFOIL MRF-50 available from Mitsubishi

Chemical Polyester Film Company) treated with a silicone release agent. The film was primarily cured by irradiation with light (at an irradiation dose of 10,000 mJ/cm²), and then the film was heat-treated at 150°C for 1 hour. Thus, a cured product (test piece) was produced. The test piece was transported through a reflow furnace at 260°C for 10 seconds. The light transmittance of the test piece was measured at a wavelength of 400 nm by means of a spectrophotometer (available from JASCO Corporation), and checked. As a result, a test piece having a light transmittance of lower than 60 % was rated as unacceptable (×), and a test piece having a light transmittance of not lower than 60 % and lower than 70 % was rated as acceptable (Δ). Further, a test piece having a light transmittance of not lower than 70 % was rated as excellent (○).

[0065]

Table 1

(parts)

		Example							
		1	2	3	4	5	6	7	8
Epoxy resins	a-1	-	-	70	75	70	60	80	-
	a-2	10	35	-	-	-	-	-	-
	a-3	-	-	5	-	-	-	-	-
Other additives	c-1	80	30	-	-	-	-	-	75
	c-2	-	25	25	25	30	40	20	25
	c-3	10	10	-	-	-	-	-	-
	c-4	1	1	1	1	1	1	1	1
	c-5	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
	c-6	-	-	-	-	-	-	-	-
Epoxy resin curing agent	b-1	0.8	1	1	1	1	0.8	1	1
Biphenyl epoxy resin (YX4000)		-	-	-	-	-	-	-	-
Biphenyl epoxy resin (YX4000H)		-	-	-	-	-	-	-	-
Solid refractive index Evaluation		1.60 o	1.61 o	1.61 o	1.62 o	1.63 o	1.64 o	1.60 o	1.59 o
Abbe number Evaluation		28 o	28 o	27 o	25 o	25 o	24 o	29 o	29 o
Viscosity (Pa·s) at 25 °C Evaluation		13.0 o	14.0 o	6.8 o	2.0 o	3.0 o	8.7 o	0.1 o	18.0 o
Viscosity (Pa·s) at 40 °C Evaluation		1.6 o	1.2 o	0.9 o	0.6 o	1.0 o	1.3 o	0.05 o	2.5 o
Thermal discoloration resistance (a) (%) Evaluation		92 o	83 o	87 o	89 o	90 o	91 o	91 o	88 o
Thermal discoloration resistance (b) (%) Evaluation		70 o	70 o	70 o	73 o	72 o	71 o	73 o	69 Δ

[0066]

Table 2

(parts)

		Comparative Example				
		1	2	3	4	5
Epoxy resins	a-1	-	-	40	-	50
	a-2	-	-	-	-	-
	a-3	-	-	-	-	-
Other additives	c-1	-	-	-	35	-
	c-2	50	50	60	-	-
	c-3	-	-	-	10	-
	c-4	1	1	1	55	-
	c-5	0.5	0.5	0.5	0.5	0.5
	c-6	-	-	-	-	50
Epoxy resin curing agent	b-1	1	1	0.8	3	1
Biphenyl epoxy resin (YX4000)		50	-	-	-	-
Biphenyl epoxy resin (YX4000H)		-	50	-	-	-
Solid refractive index Evaluation		1.62 o	1.62 o	1.65 o	1.53 x	1.66 o
Abbe number Evaluation		25 o	25 o	24 o	43 x	19 x
Viscosity (Pa·s) at 25 °C Evaluation		>100 x	>100 x	>100 x	3.0 o	38 x
Viscosity (Pa·s) at 40 °C Evaluation		17.0 x	19.0 x	16.0 x	0.04 x	4.8 o
Thermal discoloration resistance (a) (%) Evaluation		81 o	80 o	90 o	92 o	81 o
Thermal discoloration resistance (b) (%) Evaluation		25 x	24 x	70 o	82 o	63 Δ

[0067] The above results indicate that the optical component resin compositions of Examples each having a lower viscosity, a higher refractive index and a smaller Abbe number were more excellent in transparency than the optical component resin compositions of Comparative Examples. Therefore, an optical component (e.g., an optical lens) having a higher refractive index and a higher thermal discoloration resistance can be provided by using any of the optical component resin compositions of Examples. Further, the optical component produced by using any of the resin compositions of Examples is free from discoloration even with application of heat during the solder reflow process, and has stable mechanical properties against thermal stress. Therefore, the optical component is advantageously used when an imaging device is mounted by the solder reflow process in a single process step.

[0068] In contrast, the optical component resin compositions of Comparative Examples 1 to 3, which each had a very high viscosity at 25°C and a very high viscosity at 40°C, were poorer in handlability. Particularly, the optical component resin compositions of Comparative Examples 1 and 2, which each had a low transparency, is apparently unsuitable as an optical component material. The optical component resin

composition of Comparative Example 4, which had a greater Abbe number and a lower refractive index in a cured state and had an excessively low viscosity at 40°C, had difficulty in liquid amount control when a predetermined amount of the resin composition is applied dropwise. The optical component resin composition of Comparative Example 5, which had a smaller Abbe number in a cured state and had a higher viscosity at 25°C, was poorer in handlability. Further, the optical component resin composition of Comparative Example 5 became turbid when being allowed to stand at the ordinary temperature for several hours. This means that the resin composition of Comparative Example 5 was not practically usable.

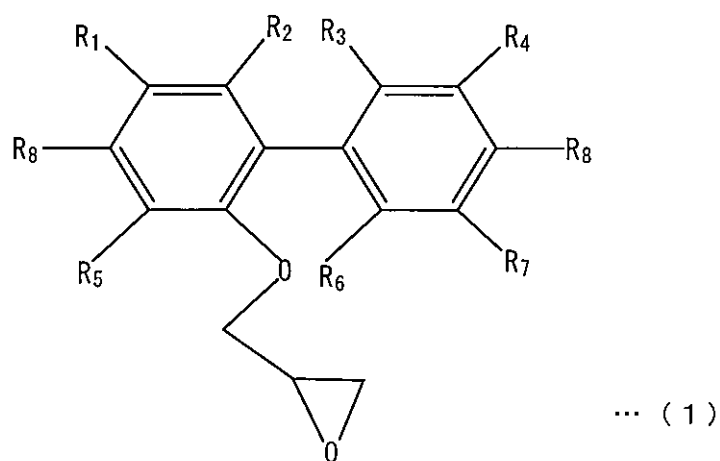
[0069] While specific forms of the embodiment of the present invention have been shown in the aforementioned inventive examples, the inventive examples are merely illustrative of the invention but not limitative of the invention. It is contemplated that various modifications apparent to those skilled in the art could be made within the scope of the invention.

[0070] The optical component resin composition according to the present invention can provide a three-dimensional product (cured product) having a higher transparency and a higher refractive index.

Therefore, the inventive resin composition is useful as a material for forming an optical component such as an optical lens (optical component material) and as a photocurable adhesive agent for bonding optical components and the like in optical applications. Further, an optical component produced by using the inventive optical component resin composition is highly reliable, and is usable as an optical lens and other optical component (optical product).

CLAIMS

1. An optical component resin composition which has a viscosity of 0.1 to 20 Pa·s at 25°C, and has a refractive index of not less than 1.57 and an Abbe number of 20 to 40 in a cured state.
2. The optical component resin composition according to claim 1, which has a viscosity of 0.05 to 5.0 Pa·s at 40°C.
3. The optical component resin composition according to claim 1 or 2, which has a transparency of not less than 80 % at a wavelength of 400 nm in a cured state.
4. The optical component resin composition according to any one of claims 1 to 3, which comprises an epoxy resin represented by the following general formula (1):



wherein R_1 to R_7 , which may be the same or different,

are each C_nH_{2n+1} (wherein n is a positive number of 1 to 5), H, a monovalent aromatic ring, an aromatic ring connected via a carbon atom or an oxygen atom, an alcoholic hydroxyl group or a glycidyl ether group, and R_8 is H.

5. The optical component resin composition according to claim 4, wherein the epoxy resin represented by the above general formula (1) has a refractive index of not less than 1.57 and a melting point of not higher than 90°C.

6. The optical component resin composition according to claim 5, which further comprises a fluorene epoxy resin having a refractive index of not less than 1.60.

7. An optical component comprising a cured product of the optical component resin composition according to any one of claims 1 to 6.