

DESCRIPTION

EPOXY RESIN COMPOSITION AND ELECTRONIC COMPONENT DEVICE

Technical Field

[0001] The present invention relates to an epoxy resin composition and an electronic component device.

Background Art

[0002] In recent years, advancements have been made in high-density mounting of semiconductor elements. In association with this, in resin-sealed semiconductor devices, surface mount-type packages are now mainly adopted over conventional pin insertion-type packages. In order to increase the mounting density and reduce the mounting height, surface-mount ICs (Integrated Circuits), LSIs (Large Scale Integrations) and the like are enclosed in thin and small packages. Accordingly, the area of elements with respect to each package has been increased, and the package thickness has been reduced considerably.

[0003] In addition, these packages are different from conventional pin insertion-type packages in terms of mounting method. In other words, in pin insertion-type packages, pins are inserted into a wiring board and then soldered on the backside of the wiring board, so that the packages are not directly exposed to a high temperature. However, in surface mount-type ICs, since elements are provisionally fixed on the surface of a wiring board and then treated in a solder bath, a reflow apparatus or the like, the packages are directly exposed to a soldering temperature (reflow temperature). Consequently, when the packages have absorbed moisture, the absorbed moisture is vaporized, and the thus generated vapor pressure acts as a peeling stress to cause detachment between an insert, such as an element or a lead frame, and a sealing material, resulting in cracking of the packages and deterioration of electrical characteristics. Therefore, it is desired to develop a sealing material having excellent solder heat resistance (reflow resistance).

[0004] For sealing materials, not only low hygroscopicity but also an improvement in adhesion or cohesion with different materials of a lead frame (whose material is Cu, Ag, Au, Pd or the like), a chip interface and the like are strongly demanded. In order to meet these demands, various studies have been conducted on epoxy resins used as main materials and, for instance, a method of using a biphenyl-type epoxy resin has been examined (see, for example, Patent Document 1). Further, based on the above-described background, studies have been conducted on various epoxy resin modifiers, examples of which include sulfur atom-containing compounds (see, for example, Patent Documents 2 and 3) and sulfur atom-containing silane coupling agents (see, for example, Patent Document 4).

Related Art Documents

Patent Documents

[0005] [Patent Document 1] Japanese Patent Application Laid-Open (JP-A) No. S64-65116

[Patent Document 2] JP-A No. H11-12442

[Patent Document 3] JP-A No. 2002-3704

[Patent Document 4] JP-A No. 2000-103940

SUMMARY OF INVENTION

Technical Problem

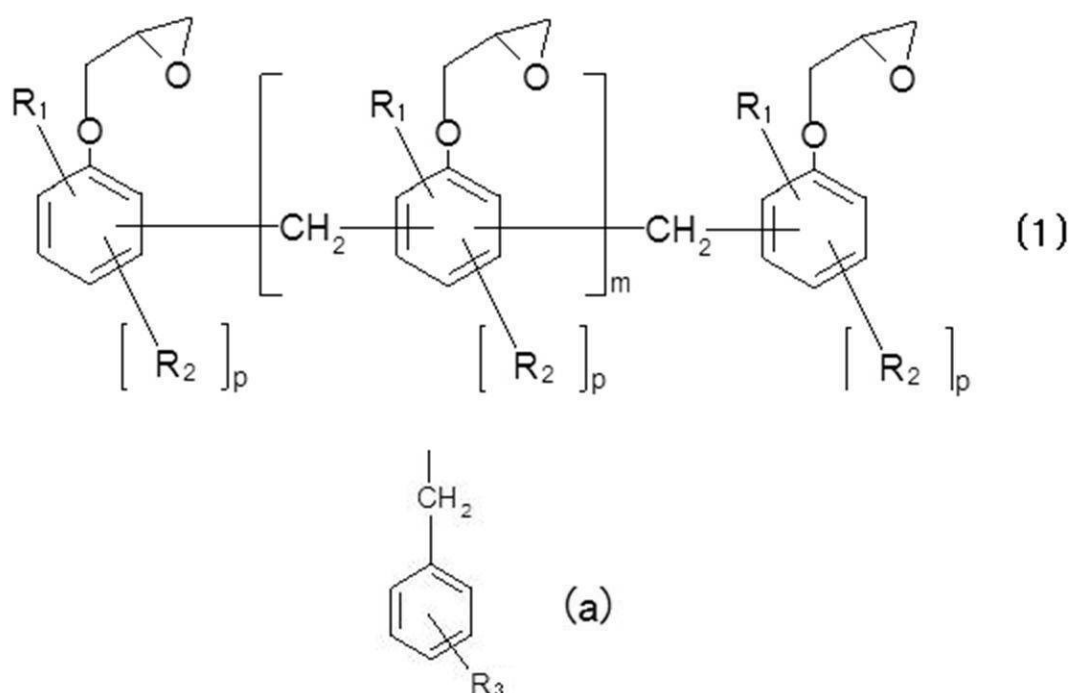
[0006] However, the use of a sulfur atom-containing silane coupling agent (see, for example, Patent Document 4) has a poor effect of improving the adhesion with noble metals, such as Ag and Au, and an addition of a sulfur atom-containing compound (see, for example, Patent Documents 2 and 3) in an amount disclosed in the respective documents does not sufficiently improve the adhesion with noble metals, neither of these measures attaining satisfactory reflow resistance.

[0007] Embodiments of the invention were made in view of the above-described circumstances, and an object of the invention is to provide: an epoxy resin composition which has excellent reflow resistance and exhibits favorable flame retardancy without a reduction in fluidity, and an electronic component device including an element sealed with the epoxy resin composition.

Solution to Problem

[0008] The present inventors intensively studied to solve the above-described problems and consequently discovered that the above-described object can be achieved by an epoxy resin composition containing a specific epoxy resin.

[0009] <1> An epoxy resin composition comprising: an epoxy resin containing a compound represented by the following Formula (1); and a curing agent containing at least one selected from the group consisting of biphenylene-type phenol aralkyl resins, phenol aralkyl resins and triphenylmethane-type phenol resins:



wherein, in Formula (1), each R_1 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms; each R_2 represents a substituent represented by Formula (a); m represents a number from 0 to 20; p represents from 0.5 to 2.0; and each R_3 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms.

[0010] <2> The epoxy resin composition according to <1>, further comprising a curing accelerator.

[0011] <3> The epoxy resin composition according to <2>, wherein the curing accelerator comprises an adduct of a tertiary phosphine compound and a quinone compound.

[0012] <4> The epoxy resin composition according to any one of <1> to <3>, further comprising an inorganic filler.

[0013] <5> The epoxy resin composition according to <4>, wherein a content ratio of the inorganic filler is from 60% by mass to 95% by mass.

[0014] <6> The epoxy resin composition according to any one of <1> to <5>, further comprising a coupling agent.

[0015] <7> The epoxy resin composition according to <6>, wherein the coupling agent comprises a secondary amino group-containing silane coupling agent.

[0016] <8> An electronic component device comprising: an element; and a cured product of the epoxy resin composition according to any one of <1> to <7>, which seals the element.

Effects of Invention

[0017] According to embodiments of the invention, an epoxy resin composition which has excellent reflow resistance and exhibits favorable flame retardancy without a reduction in fluidity, and an electronic component device including an element sealed with the epoxy resin composition can be obtained.

DESCRIPTION OF EMBODIMENTS

Mode for Carrying Out the Invention

[0018] In the present specification, those numerical ranges that are expressed with "to" each denote a range that includes the numerical values stated before and after "to" as the minimum value and the maximum value, respectively.

In the present specification, when there are plural kinds of substances that correspond to a component of a composition, the indicated content ratio of the component in the composition means, unless otherwise specified, the total content ratio of the plural kinds of substances existing in the composition.

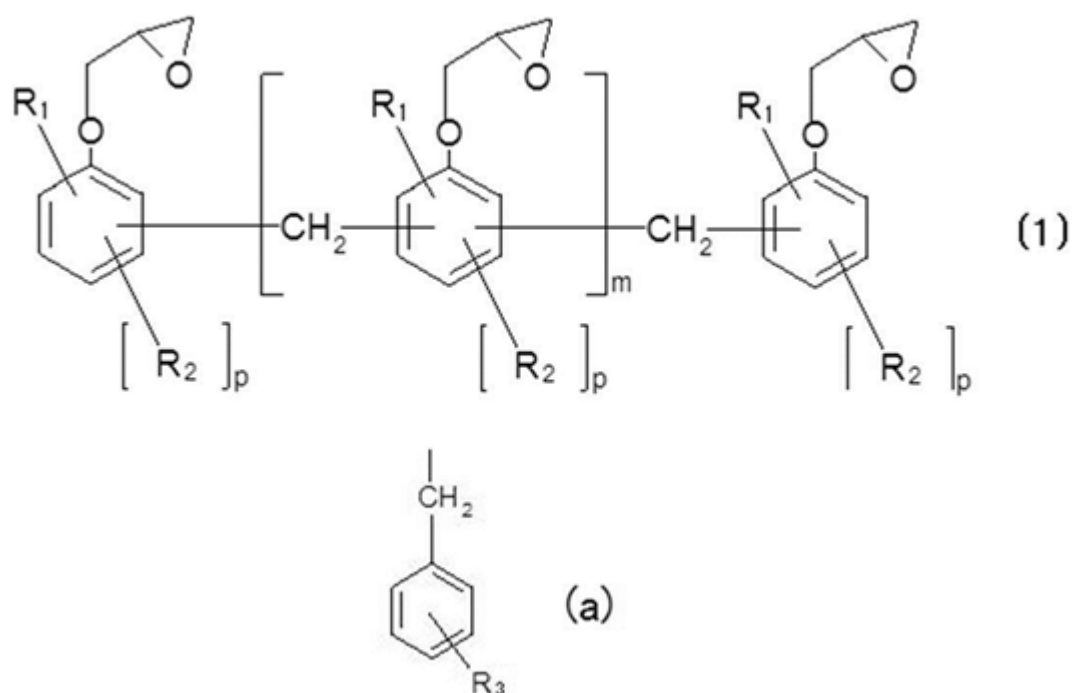
In a set of numerical ranges that are stated stepwise in the present specification, the upper limit value or the lower limit value of a numerical range may be replaced with the upper limit value or the lower limit value of other numerical range. Further, in a numerical range stated in the present specification, the upper limit value or the lower limit value of the numerical range may be replaced with a value indicated in Examples.

In the present specification, when there are plural kinds of particles that correspond to a component of a composition, the indicated particle size of the component in the composition means, unless otherwise specified, a value determined for a mixture of the plural kinds of particles existing in the composition.

[0019] <Epoxy Resin Composition>

The epoxy resin composition according to one embodiment of the invention includes: an epoxy resin containing a compound represented by the following Formula (1) (hereinafter, also referred to as "specific epoxy resin"); and a curing agent containing at least one selected from the group consisting of biphenylene-type phenol aralkyl resins, phenol aralkyl resins, and triphenylmethane-type phenol resins (hereinafter, also referred to as "specific curing agent").

[0020]



[0021] Each R_1 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms; each R_2 represents a substituent represented by Formula (a); m represents a number from 0 to 20; p represents from 0.5 to 2.0; and each R_3 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms.

[0022] By configuring the epoxy resin composition in this manner, since the adhesion with metals such as Cu, Ag, Au and Pd is improved, the epoxy resin composition is imparted with excellent reflow resistance and favorable flame retardancy without a reduction in fluidity. The reason for this is not clear; however, it is believed as follows.

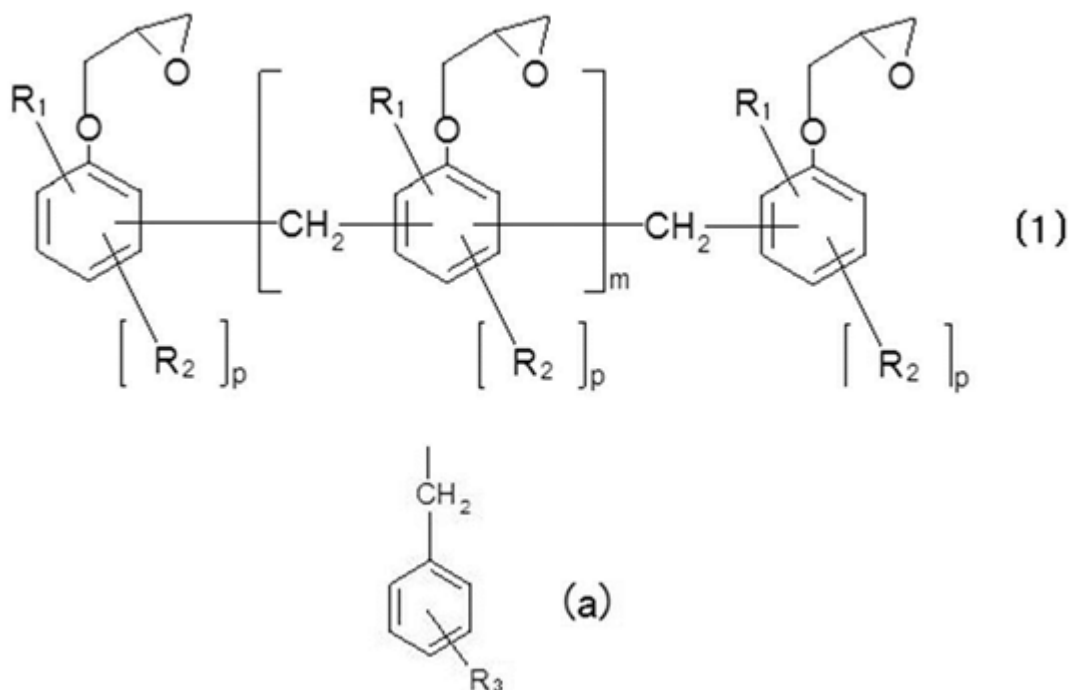
[0023] By introducing a specific amount of benzyl group into an epoxy resin that is an epoxidized novolac-type phenol resin, the interaction of the epoxy resin with an adherend is facilitated and the adhesion is thus improved. In addition, it is believed that the moisture resistance is improved and the occurrence of detachment from an insert such as a lead frame caused by absorbed moisture is suppressed, so that the adhesion is maintained even in a reflow process where the epoxy resin is exposed to high-temperature heat, and the reflow resistance is thereby improved. Particularly, by using a specific curing agent in combination, since the adhesion with Ag that may be used as a lead frame material is improved, the reflow resistance is also improved synergistically.

Moreover, it is believed that, because of a reduction in melt viscosity, the fluidity is improved and excellent moldability is attained.

[0024] (Epoxy Resin)

The epoxy resin composition includes an epoxy resin. This epoxy resin contains a compound represented by the following Formula (1).

[0025]



[0026] Each R_1 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms; each R_2 represents a substituent represented by Formula (a); m represents a number from 0 to 20; p represents from 0.5 to 2.0; and each R_3 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms.

[0027] In Formula (1), R_2 represents a substituent represented by Formula (a) (hereinafter, also referred to as "benzyl group"). The p represents a number from 0.5 to 2.0, which means an average number (number-average) of benzyl groups substituting a single benzene ring. The p is from 0.5 to 2.0, preferably from 0.7 to 1.5. The reflow resistance is further improved when the p is 0.7 or larger, while the curability is further improved when the p is 1.5 or smaller.

[0028] This p will now be described. In the compound represented by Formula (1), the benzene rings on the respective ends can be substituted with a maximum of three benzyl groups, and the benzene ring in the middle can be substituted with a maximum of two benzyl groups; therefore, when the m is 1, the maximum total number of benzyl groups is 8, and the maximum value of the p is 2.7 ($8/3 \approx 2.7$). However, in this embodiment, the p in Formula (1) is from 0.5 to 2.0. In this embodiment, since the p is a number-average value, the benzene rings in Formula (1) may include a hydrogen atom that is not substituted with a

benzyl group.

[0029] In Formula (a), each R_3 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms, and is preferably a hydrogen atom or an alkyl group having from 1 to 3 carbon atoms, more preferably a hydrogen atom.

[0030] In Formula (1), each R_1 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms, and is preferably a hydrogen atom or an alkyl group having from 1 to 3 carbon atoms, more preferably a hydrogen atom or a methyl group. Each R_1 may be bound at any of *ortho*-, *meta*- and *para*-positions of the respective benzene rings; however, each R_1 is preferably bound at the *ortho*-position.

[0031] In Formula (1), the m is an average value, representing a number from 0 to 20, preferably from 1.0 to 5.0.

[0032] The melt viscosity of the specific epoxy resin at 150°C is preferably from 0.01 Pa·s to 0.30 Pa·s, more preferably from 0.01 Pa·s to 0.20 Pa·s. From the standpoint of workability, the lower the melt viscosity within this range, the more preferred it is.

[0033] The melt viscosity is determined by the following method using a rotary viscoelasticity analyzer (e.g., trade name: CFD-100D, manufactured by Shimadzu Corporation).

(1) The temperature range is set at 150°C, and (2) from 0.15 g to 0.25 g of a sample is melted on a plate, a cone is lowered, and then the sample is left to stand until a temperature control lamp blinks five times. (3) The sample is stirred by vertically moving the cone for about 20 seconds, and the sample is subsequently left to stand until the temperature control lamp blinks five times. (4) After rotating the cone, the value is read after about 15 seconds. (5) The operations of (3) and (4) are repeated until the value becomes constant, and this value is recorded. (6) The operations of (2) to (5) are repeated at least three times for the same lot, and the average value thereof is taken as the viscosity.

[0034] The epoxy equivalent of the specific epoxy resin is preferably from 240 g/eq to 270 g/eq, more preferably from 255 g/eq to 270 g/eq, still more preferably from 257 g/eq to 270 g/eq, particularly preferably from 259 g/eq to 270 g/eq.

[0035] The epoxy equivalent is determined by the following method.

In a 100-mL flask, the epoxy resin is weighed in an amount of from 3 g to 4 g in terms of solid content, and 20 mL of acetic acid, 10 mL of a tetraethylammonium bromide acetic acid solution (a mixture of 100 g of tetraethylammonium bromide and 400 mL of acetic acid) and 4 to 5 droplets of crystal violet are added thereto. The resulting solution is titrated with a 0.1 mol/L perchloric acid-acetic acid solution. A blank is also titrated in the same manner. The epoxy equivalent is calculated by the following equation.

[0036]
$$\text{Epoxy equivalent} = 1,000 \times \text{Mass of actually weighted epoxy resin [g]} \times \text{Solid concentration of epoxy resin [\% by mass]} / ((\text{Titer [mL]} - \text{Blank titer [mL]}) \times 0.1 \text{ mol/L} \times$$

Factor (f) of perchloric acid-acetic acid solution)

[0037] From the standpoints of moldability and reflow resistance, the softening point of the specific epoxy resin is preferably from 50°C to 80°C, more preferably from 55°C to 70°C, still more preferably from 56°C to 65°C. The softening point of the specific epoxy resin is determined by a ring-and-ball method. In the ring-and-ball method, a resin is set on a support ring in a water bath, a ball of 3.5 ± 0.05 g in weight is placed on the center of the ring, and the bath temperature is then raised at a rate of $5 \pm 0.5^\circ\text{C}/\text{min}$, after which the temperature is measured when the resin hangs down due to the weight of the ball. The details of this measurement conform to JIS K7234:1986.

[0038] The specific epoxy resin can be obtained by allowing a phenol novolac resin corresponding to Formula (1) (hereinafter, also referred to as "raw material phenol novolac resin") to react with a benzyl group-containing compound corresponding to Formula (a) (hereinafter, also referred to as "raw material benzyl group-containing compound") in the presence of an acid catalyst so as to prepare a specific phenol novolac resin, and subsequently epoxidizing this specific phenol novolac resin.

[0039] The blending ratio of the raw material phenol novolac resin and the raw material benzyl group-containing compound is adjusted in accordance with the desired p value in Formula (1). Accordingly, it is preferred to blend the raw material phenol novolac resin and the raw material benzyl group-containing compound such that the raw material benzyl group-containing compound is added in an amount of preferably from 0.5 to 2.0 molecules, more preferably from 0.7 to 1.5 molecules, with respect to one benzene ring of the raw material phenol novolac resin. Since each benzene ring of the raw material phenol novolac resin has a single hydroxyl group, the blending ratio of the raw material benzyl group-containing compound is preferably from 0.5 mol to 2.0 mol, more preferably from 0.7 mol to 1.5 mol, with respect to 1 mol of hydroxyl group in the raw material phenol novolac resin.

[0040] The raw material phenol novolac resin has a structure in which phenol compounds having R_1 (a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms) are linked via methylene groups. Examples of the phenol compounds include phenols, cresols, ethylphenol, isopropylphenol, *n*-propylphenol, isobutylphenol, *t*-butylphenol, *n*-pentylphenol, and *n*-hexylphenol. Thereamong, as the phenol compounds, *o*-cresol or a cresol containing *o*-cresol as a main component is preferred. When a cresol containing *o*-cresol as a main component is used, the content ratio of *o*-cresol with respect to the whole cresol is preferably not less than 50% by mass, more preferably not less than 70% by mass. When a cresol containing *o*-cresol as a main component is used, the cresol containing *o*-cresol as a main component may also contain *m*-cresol and *p*-cresol.

[0041] In addition to the structure in which phenol compounds having R_1 are linked via methylene groups, the raw material phenol novolac resin may partially have a structure in

which other phenol compounds are linked via methylene groups. Examples of such other phenol compounds include allylphenol, phenylphenol, 2,6-xyleneol, 2,6-diethylphenol, hydroquinone, resorcin, catechol, 1-naphthol, 2-naphthol, 1,5-naphthalenediol, 1,6-naphthalenediol, 1,7-naphthalenediol, 2,6-naphthalenediol, and 2,7-naphthalenediol. The compound represented by Formula (1) may partially contain a structural unit derived from other phenol compound, and the compound represented by Formula (1) contains a structural unit derived from other phenol compound in an amount of preferably 10% by mass or less, more preferably 5% by mass or less, with respect to all structural units. It is more preferred that the compound represented by Formula (1) does not substantially contain any structural unit derived from other phenol compound.

[0042] The raw material benzyl group-containing compound is a benzyl group-containing compound having R_3 (a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms). Examples of the raw material benzyl group-containing compound include benzyl alcohol, benzyl chloride, benzyl bromide, and benzyl iodide. The raw material benzyl group-containing compound, such as benzyl alcohol, benzyl chloride, benzyl bromide or benzyl iodide, may also have a monovalent hydrocarbon group having from 1 to 6 carbon atoms as R_3 . Examples of the monovalent hydrocarbon group having from 1 to 6 carbon atoms include a methyl group, an ethyl group, a propyl group, a butyl group, an isopropyl group, an isobutyl group, a *t*-butyl group, a pentyl group, and a hexyl group.

[0043] The acid catalyst may be selected as appropriate from well-known inorganic acids and organic acids. Specific examples of the acid catalyst include mineral acids, such as hydrochloric acid, sulfuric acid, and phosphoric acid; organic acids, such as formic acid, oxalic acid, trifluoroacetic acid, *p*-toluenesulfonic acid, dimethyl sulfate, and diethyl sulfate; Lewis acids, such as zinc chloride, aluminum chloride, iron chloride, and boron trifluoride; and solid acids, such as ion exchange resins, activated clay, silica-alumina, and zeolite.

[0044] The reaction for synthesizing the specific phenol novolac resin is usually performed at a temperature of from 10°C to 250°C for 1 hour to 20 hours. In the reaction, a solvent may also be used. Examples of the solvent include alcohol solvents, such as methanol, ethanol, propanol, butanol, ethylene glycol, methyl cellosolve, and ethyl cellosolve; ketone solvents, such as acetone, methyl ethyl ketone, and methyl isobutyl ketone; ether solvents, such as dimethyl ether, diethyl ether, diisopropyl ether, tetrahydrofuran, and dioxane; and aromatic compounds, such as benzene, toluene, chlorobenzene, and dichlorobenzene.

[0045] This reaction is performed by, for example, a method in which the raw material phenol novolac resin and the raw material benzyl group-containing compound are added all at once and allowed to react as they are at a prescribed temperature, or a method in which the raw material phenol novolac resin and a catalyst are added and, while maintaining the

resultant at a prescribed temperature, the raw material benzyl group-containing compound is dropped thereto and allowed to react. In the latter method, the dropping time is usually from 1 hour to 10 hours, preferably 5 hours or shorter. In cases where a solvent is used, the catalyst is removed after the reaction as required, and the solvent is subsequently removed by distillation to obtain the specific phenol novolac resin.

[0046] Examples of a method of epoxidizing the specific phenol novolac resin include a method of allowing the specific phenol novolac resin to react with epichlorohydrin, and a method of preparing an allyl ether compound by reaction between the specific phenol novolac resin and an allyl halide and subsequently allowing this ally ether compound to react with peroxide.

[0047] For example, a method of dissolving the specific phenol novolac resin in excess epichlorohydrin and subsequently allowing the resulting mixture to react in the presence of an alkali metal hydroxide, such as sodium hydroxide or potassium hydroxide, in a temperature range of from 20°C to 150°C, preferably from 30°C to 80°C, for 1 hour to 10 hours may be employed. In this case, the alkali metal hydroxide is used in an amount of preferably from 0.8 mol to 1.5 mol, more preferably from 0.9 mol to 1.2 mol, with respect to 1 mol of hydroxyl group of the specific phenol novolac resin. Further, epichlorohydrin is used in excess with respect to 1 mol of hydroxyl group of the specific phenol novolac resin, usually in a range of from 1.5 mol to 30 mol, preferably from 2 mol to 15 mol, with respect to 1 mol of hydroxyl group of the specific phenol novolac resin. After the completion of the reaction, the excess epichlorohydrin is removed by distillation, and residues are dissolved in a solvent such as toluene or methyl isobutyl ketone, filtered and then washed with water to remove inorganic salts, followed by removal of the solvent by distillation, whereby the desired specific epoxy resin can be obtained.

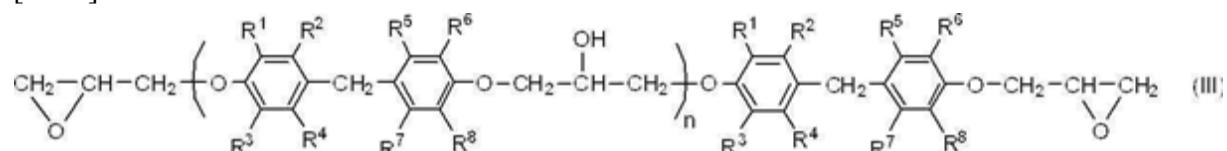
[0048] In the epoxy resin composition, in addition to the specific epoxy resin, a conventionally known epoxy resin may also be used in combination. Examples of an epoxy resin that can be used in combination include novolac-type epoxy resins [e.g., phenol novolac-type epoxy resins (excluding the specific epoxy resin), *o*-cresol novolac-type epoxy resins (excluding the specific epoxy resin), and triphenylmethane-type epoxy resins], which are prepared by epoxidizing a novolac resin obtained by condensation or co-condensation of at least one selected from the group consisting of phenol compounds (e.g., phenol, cresol, xylenol, resorcin, catechol, bisphenol A and bisphenol F) and naphthol compounds (e.g., α -naphthol, β -naphthol and dihydroxynaphthalene) with an aldehyde group-containing compound (e.g., formaldehyde, acetaldehyde, propionaldehyde, benzaldehyde, or salicylaldehyde) in the presence of an acidic catalyst; epoxy resins that are diglycidyl ethers, such as bisphenol A, bisphenol F, bisphenol S, and alkyl-substituted or unsubstituted biphenols; stilbene-based epoxy resins; hydroquinone-based epoxy resins; glycidyl ester-type epoxy resins obtained by reaction between a polybasic acids, such as phthalic acid or dimer acid, and epichlorohydrin; glycidylamine-type epoxy resins obtained

by reaction between a polyamine, such as diaminodiphenylmethane or isocyanuric acid, and epichlorohydrin; dicyclopentadiene-type epoxy resins that are epoxidized co-condensed resins of dicyclopentadiene and a phenol compound; naphthalene-type epoxy resins having a naphthalene ring; phenol aralkyl-type epoxy resins that are epoxidized phenol aralkyl resins; biphenylene skeleton-containing biphenylene-type epoxy resins; naphthol aralkyl-type epoxy resins that are epoxidized naphthol aralkyl resins; trimethylolpropane-type epoxy resins; terpene-modified epoxy resins; linear aliphatic epoxy resins obtained by oxidation of olefin bonds with a peracid such as peracetic acid; alicyclic epoxy resins; and sulfur atom-containing epoxy resins. These epoxy resins that can be used in combination may be used individually, or in combination of two or more kinds thereof.

[0049] Among these epoxy resins that can be used in combination, bisphenol F-type epoxy resins, sulfur atom-containing epoxy resins and phenol aralkyl-type epoxy resins are preferred from the standpoints of fluidity and reflow resistance; novolac-type epoxy resins (excluding the specific epoxy resin) are preferred from the standpoint of curability; dicyclopentadiene-type epoxy resins are preferred from the standpoint of low hygroscopicity; naphthalene-type epoxy resins and triphenylmethane-type epoxy resins are preferred from the standpoints of heat resistance and low warpage; and biphenylene-type epoxy resins and naphthol aralkyl-type epoxy resins are preferred from the standpoint of flame retardancy. From the standpoint of improving the high-temperature storage performance, it is preferred to use an epoxy resin having favorable flame retardancy in combination so as to obtain an epoxy resin composition of a non-halogenated type, a non-antimony type or the like.

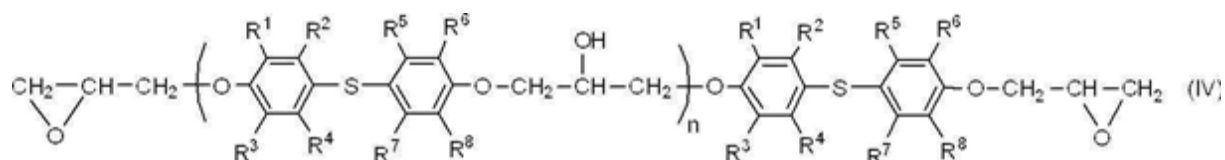
[0050] Examples of the bisphenol F-type epoxy resins include epoxy resins represented by the following Formula (III), and examples of the sulfur atom-containing epoxy resins include epoxy resins represented by the following Formula (IV). Examples of the phenol aralkyl-type epoxy resins include epoxy resins represented by the following Formula (V).

[0051]



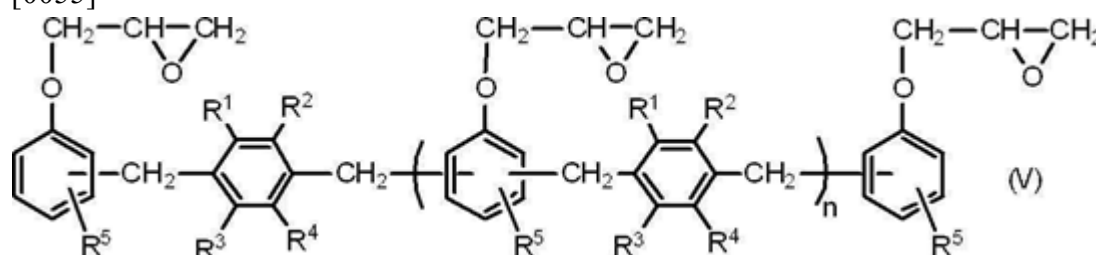
[0052] In Formula (III), each of R¹ to R⁸ independently represents a hydrogen atom, an alkyl group having from 1 to 10 carbon atoms, an alkoxy group having from 1 to 10 carbon atoms, an aryl group having from 6 to 10 carbon atoms, or an aralkyl group having from 7 to 10 carbon atoms, and n is an average value, representing a number from 0 to 3. Each of the alkyl group, the alkoxy group, the aryl group and the aralkyl group that are represented by R¹ to R⁸ may independently have a substituent, or have no substituent.

[0053]



[0054] In Formula (IV), each of R^1 to R^8 independently represents a hydrogen atom, an alkyl group having from 1 to 10 carbon atoms or an alkoxy group having from 1 to 10 carbon atoms, and n is an average value, representing a number from 0 to 3. Each of the alkyl group and the alkoxy group that are represented by R^1 to R^8 may independently have a substituent, or have no substituent.

[0055]



[0056] In Formula (V), each of R^1 to R^5 independently represents a hydrogen atom, an alkyl group having from 1 to 6 carbon atoms, or an alkoxy group having from 1 to 2 carbon atoms, and n is an average value, representing a number from 0 to 3. Each of the alkyl group and the alkoxy group that are represented by R^1 to R^5 may independently have a substituent, or have no substituent.

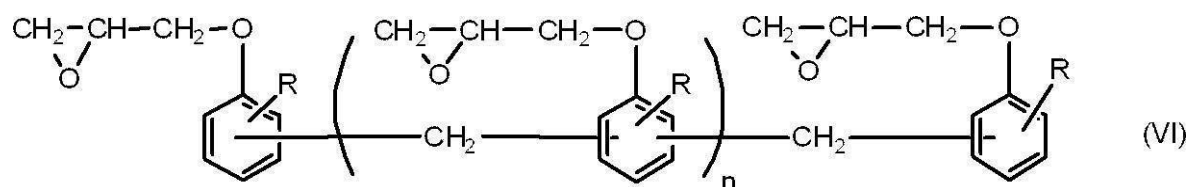
[0057] As a bisphenol F-type epoxy resin represented by Formula (III), for example, YSLV-80XY (trade name, manufactured by Nippon Steel & Sumikin Chemical Co., Ltd.), which contains an epoxy resin wherein R^1 , R^3 , R^6 and R^8 are methyl groups, R^2 , R^4 , R^5 and R^7 are hydrogen atoms, and $n = 0$ as a main component, is available as a commercial product.

[0058] Among sulfur atom-containing epoxy resins represented by Formula (IV), epoxy resins wherein R^2 , R^3 , R^6 and R^7 are hydrogen atoms and R^1 , R^4 , R^5 and R^8 are alkyl groups are preferred, and epoxy resins wherein R^2 , R^3 , R^6 and R^7 are hydrogen atoms, R^1 and R^8 are *t*-butyl groups and R^4 and R^5 are methyl groups are more preferred. As such a compound, for example, YSLV-120TE (trade name, manufactured by Nippon Steel & Sumikin Chemical Co., Ltd.) is available as a commercial product.

[0059] As an epoxy resin represented by Formula (V), for example, NC-2000L (trade name, manufactured by Nippon Kayaku Co., Ltd.) wherein R^1 to R^5 are hydrogen atoms is available as a commercial product. Any one of these epoxy resin may be used singly, or two or more kinds thereof may be used in combination.

[0060] Examples of the novolac-type epoxy resins include epoxy resins represented by the following Formula (VI).

[0061]

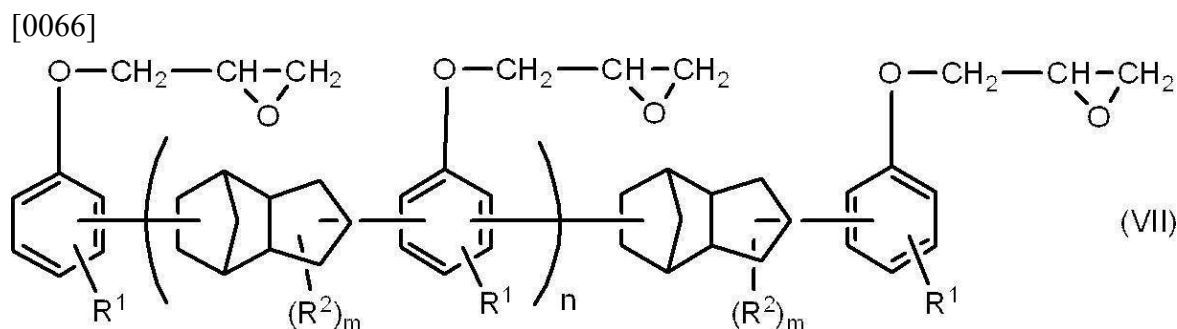


[0062] In Formula (VI), each R independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 10 carbon atoms (with a proviso that each R is not the substituent represented by Formula (a) in Formula (1)), and n is an average value, representing a number from 0 to 10. Each of the hydrocarbon groups represented by Rs may independently have a substituent, or have no substituent.

[0063] A novolac-type epoxy resin represented by Formula (VI) can be obtained by allowing a novolac-type phenol resin with epichlorohydrin. Particularly, in Formula (VI), each R is preferably an alkyl group having from 1 to 10 carbon atoms, such as a methyl group, an ethyl group, a propyl group, a butyl group, an isopropyl group or an isobutyl group, or an alkoxy group having from 1 to 10 carbon atoms, such as a methoxy group, an ethoxy group, a propoxy group or a butoxy group, more preferably a hydrogen atom or a methyl group. The n is preferably an integer of 0 to 3.

[0064] Among novolac-type epoxy resins represented by Formula (VI), *o*-cresol novolac-type epoxy resins are preferred. As such a compound, for example, EOCN-1020 (trade name, manufactured by Nippon Kayaku Co., Ltd.) is available as a commercial product.

[0065] Examples of the dicyclopentadiene-type epoxy resins include epoxy resins represented by the following Formula (VII).



[0067] In Formula (VII), each of R¹ and R² independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 10 carbon atoms; n is an average value, representing a number from 0 to 10; and m represents an integer of 0 to 6. Each of the hydrocarbon groups represented by R¹ and R² may independently have a substituent, or have no substituent.

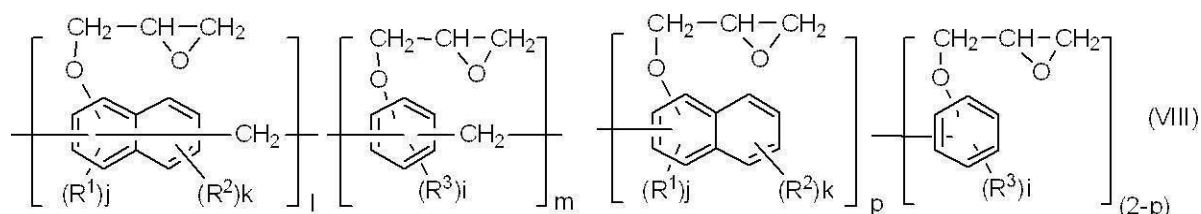
[0068] Examples of R¹ in Formula (VII) include a hydrogen atom; alkyl groups, such as a methyl group, an ethyl group, a propyl group, a butyl group, an isopropyl group, and a *t*-butyl group; alkenyl groups, such as a vinyl group, an allyl group, and a butenyl group; and substituted monovalent hydrocarbon groups having from 1 to 5 carbon atoms, such as halogenated alkyl groups, amino group-substituted alkyl groups, and mercapto

group-substituted alkyl groups. Thereamong, R^1 is preferably an alkyl group such as a methyl group or an ethyl group, or a hydrogen atom, more preferably a methyl group or a hydrogen atom.

[0069] Examples of R^2 in Formula (VII) include a hydrogen atom; alkyl groups, such as a methyl group, an ethyl group, a propyl group, a butyl group, an isopropyl group, and a *t*-butyl group; alkenyl groups, such as a vinyl group, an allyl group, and a butenyl group; and substituted monovalent hydrocarbon groups having from 1 to 5 carbon atoms, such as halogenated alkyl groups, amino group-substituted alkyl groups and mercapto group-substituted alkyl groups, among which a hydrogen atom is preferred. As such a compound, for example, HP-7200 (trade name, manufactured by DIC Corporation) is available as a commercial product.

[0070] Examples of the naphthalene-type epoxy resins include epoxy resins represented by the following Formula (VIII). Examples of the triphenylmethane-type epoxy resins include epoxy resins represented by the following Formula (IX).

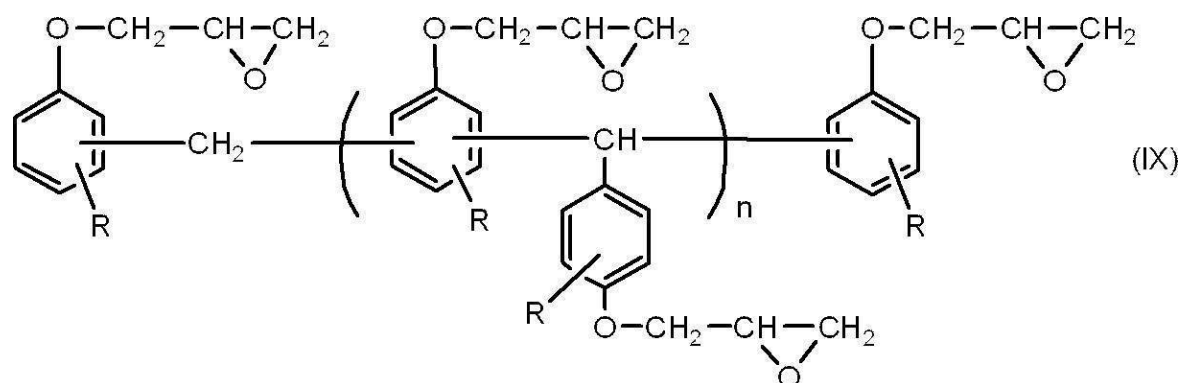
[0071]



[0072] In Formula (VIII), each of R^1 to R^3 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 12 carbon atoms; p is an average value, representing a number from 0 to 2; l and m are average values, each independently representing a number from 0 to 11, and are selected such that $(l + m)$ is from 1 to 11 and $(l + p)$ is from 1 to 12; i represents an integer of 0 to 3; j represents an integer of 0 to 2; and k represents an integer of 0 to 4. Each of the hydrocarbon groups represented by R^1 to R^3 may independently have a substituent, or have no substituent.

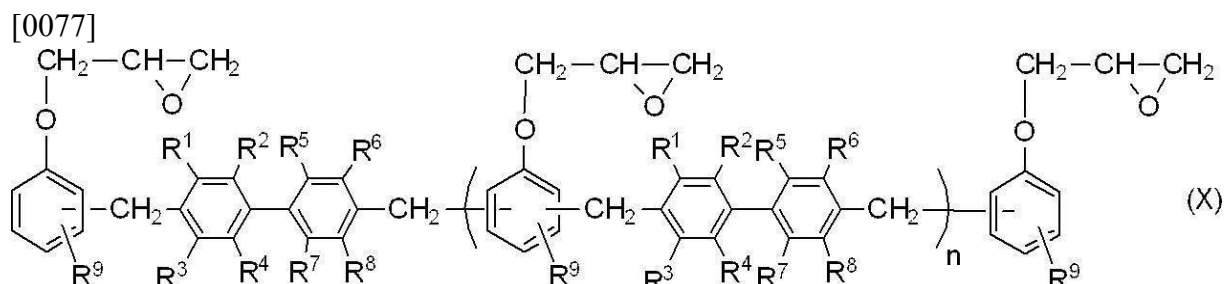
[0073] Examples of the naphthalene-type epoxy resin represented by Formula (VIII) include random copolymers randomly containing l structural units and m other structural units, alternating copolymers alternately containing such structural units, copolymers regularly containing such structural units, and block copolymers containing such structural units in blocks. Any one of these copolymers may be used singly, or two or more kinds thereof may be used in combination. As a compound wherein R^1 and R^2 are hydrogen atoms and R^3 is a methyl group, for example, NC-7000 trade name, manufactured by (Nippon Kayaku Co., Ltd.) is available as a commercial product.

[0074]

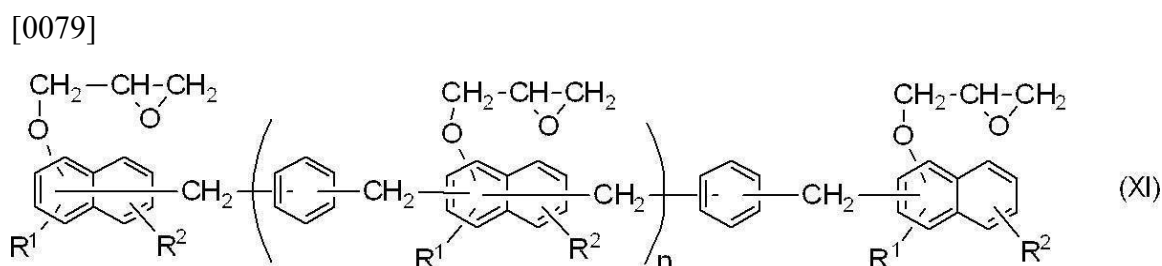


[0075] In Formula (IX), each R independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 10 carbon atoms, and n is an average value, representing a number from 0 to 10. Each of the hydrocarbon groups represented by Rs may independently have a substituent, or have no substituent. As a compound wherein Rs are hydrogen atoms, for example, E-1032 (trade name, manufactured by Mitsubishi Chemical Corporation) is available as a commercial product.

[0076] Examples of the biphenylene-type epoxy resins include epoxy resins represented by the following Formula (X). Examples of the naphthol aralkyl-type epoxy resins include epoxy resins represented by the following Formula (XI).



[0078] In Formula (X), each R^1 to R^9 independently represents a hydrogen atom, an alkyl group having from 1 to 10 carbon atoms (e.g., a methyl group, an ethyl group, a propyl group, a butyl group, an isopropyl group, or an isobutyl group), an alkoxy group having from 1 to 10 carbon atoms (e.g., a methoxy group, an ethoxy group, a propoxy group, or a butoxy group), an aryl group having from 6 to 10 carbon atoms (e.g., a phenyl group, a tolyl group, or a xylyl group), or an aralkyl group having from 7 to 10 carbon atoms (e.g., a benzyl group or a phenethyl group), among which a hydrogen atom or a methyl group is preferred; and n is an average value, representing a number from 0 to 10. Each of the alkyl group, the alkoxy group, the aryl group and the aralkyl group that are represented by R^1 to R^9 may independently have a substituent, or have no substituent.

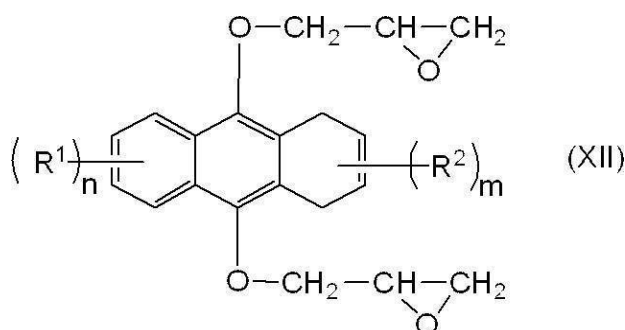


[0080] In Formula (XI), each of R^1 and R^2 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 12 carbon atoms, and n is an average value, representing a number from 0 to 10. Each of the hydrocarbon groups represented by R^1 and R^2 may independently have a substituent, or have no substituent.

[0081] As a biphenylene-type epoxy resin, for example, NC-3000 (trade name, manufactured by Nippon Kayaku Co., Ltd.) is available as a commercial product. Further, as a naphthol aralkyl-type epoxy resin, for example, ESN-175 (trade name, manufactured by Nippon Steel & Sumikin Chemical Co., Ltd.) is available as a commercial product. Any one of the above-described biphenylene-type epoxy resins may be used singly, or two or more kinds thereof may be used in combination.

[0082] Moreover, as the epoxy resin, an epoxy resin represented by the following Formula (XII) may be used as well.

[0083]



[0084] In Formula (XII), each R^1 independently represents a hydrocarbon group having from 1 to 12 carbon atoms, or an alkoxy group having from 1 to 12 carbon atoms, and n is an average value, representing a number from 0 to 4. Further, each R^2 independently represents a hydrocarbon group having from 1 to 12 carbon atoms, or an alkoxy group having from 1 to 12 carbon atoms, and m is an average value, representing a number from 0 to 2. Each of the hydrocarbon group and the alkoxy group that are represented by R^1 and R^2 may independently have a substituent, or have no substituent. Particularly, from the standpoints of flame retardancy and moldability, an epoxy resin wherein n and m are both 0 is preferred. As such a compound, for example, YX-8800 (trade name, manufactured by Mitsubishi Chemical Corporation) is available.

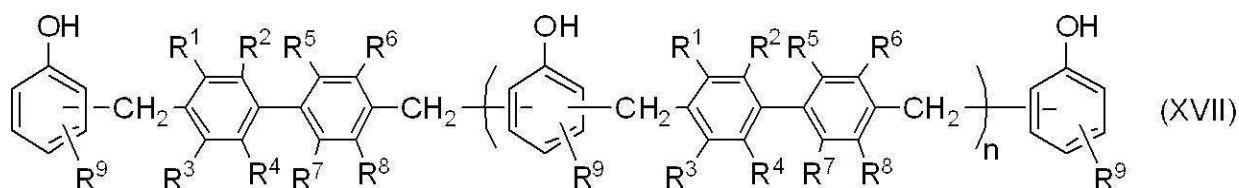
[0085] The content ratio of the specific epoxy resin is preferably not less than 30% by mass, more preferably not less than 50% by mass, still more preferably not less than 70% by mass, with respect to the total amount of the epoxy resin.

[0086] (Curing Agent)

The epoxy resin composition includes a curing agent. The curing agent contains at least one selected from the group consisting of biphenylene-type phenol aralkyl resins, phenol aralkyl resins, and triphenylmethane-type phenol resins.

[0087] The curing agent is preferably a biphenylene-type phenol aralkyl resin represented by the following Formula (XVII).

[0088]

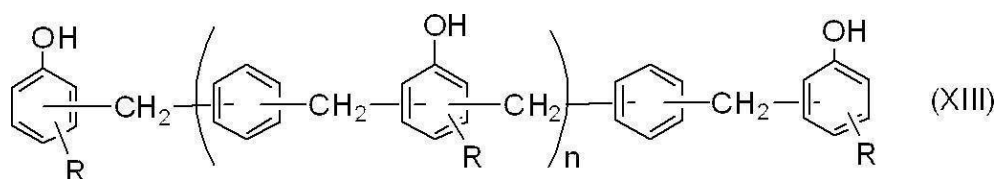


[0089] In Formula (XVII), each of R^1 to R^9 independently represents a hydrogen atom; an alkyl group having from 1 to 10 carbon atoms (e.g., a methyl group, an ethyl group, a propyl group, a butyl group, an isopropyl group, or an isobutyl group), an alkoxy group having from 1 to 10 carbon atoms (e.g., a methoxy group, an ethoxy group, a propoxy group, or a butoxy group), an aryl group having from 6 to 10 carbon atoms (e.g., a phenyl group, a tolyl group, or a xylyl group), or an aralkyl group having from 7 to 10 carbon atoms (e.g., a benzyl group or a phenethyl group), among which a hydrogen atom or a methyl group is preferred; and n is an average value, representing a number from 0 to 10. Each of the alkyl group, the alkoxy group, the aryl group and the aralkyl group that are represented by R^1 to R^9 may independently have a substituent, or have no substituent.

[0090] Examples of the biphenylene-type phenol aralkyl resin represented by Formula (XVII) include compounds wherein R^1 to R^9 are all hydrogen atoms and, thereamong, from the standpoint of melt viscosity, a condensate mixture containing a condensate wherein n is 1 or larger in an amount of not less than 50% by mass is preferred. As such a compound, for example, MEH-7851 (trade name, manufactured by Meiwa Plastic Industries, Ltd.) is available as a commercial product. When any of the above-described biphenylene-type phenol aralkyl resins is used, in order to allow the resin to exhibit its performance, the content ratio thereof is preferably not less than 30% by mass, more preferably not less than 50% by mass, with respect to the total amount of the curing agent.

[0091] From the standpoints of reflow resistance, flame retardancy and moldability, phenol aralkyl resins represented by the following Formula (XIII) are preferred.

[0092]



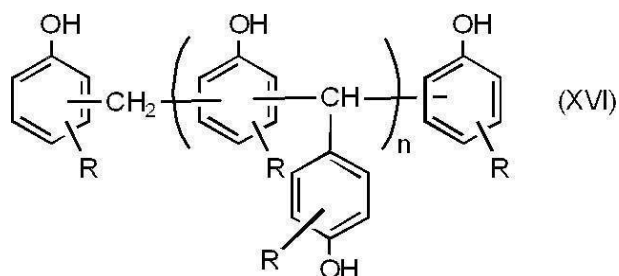
[0093] In Formula (XIII), each R independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 10 carbon atoms, and n is an average value, representing a number from 0 to 10. Each of the hydrocarbon groups represented by R s may independently have a substituent, or have no substituent.

[0094] Among compounds represented by Formula (XIII), phenol aralkyl resins wherein R s are hydrogen atoms and n is an average value of from 0 to 8 are more preferred.

Specific examples thereof include *p*-xylylene-type phenol aralkyl resins and *m*-xylylene-type phenol aralkyl resins. As such a compound, for example, XLC (trade

When any of the above-described phenol aralkyl resins is used, in order to allow the resin to exhibit its performance, the content ratio thereof is preferably not less than 30% by mass, more preferably not less than 50% by mass, with respect to the total amount of the curing agent.

[0096]



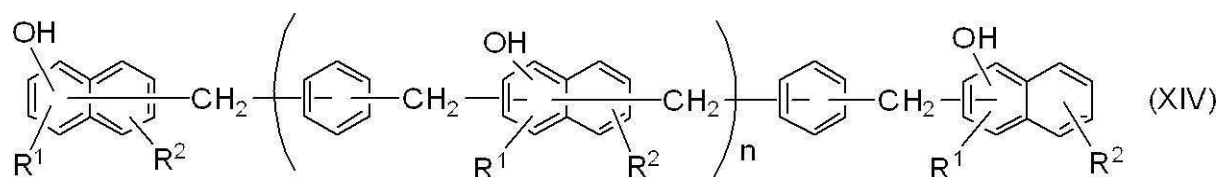
[0098] The specific curing agent may be used singly, or in combination of two or more thereof.

[0099] Examples of other curing agent include novolac-type phenol resins, naphthol aralkyl resins, dicyclopentadiene-type phenol resins, terpene-modified phenol resins, *para*-xylylene-modified phenol resins, *meta*-xylylene-modified phenol resins, melamine-modified phenol resins, cyclopentadiene-modified phenol resins, and phenol resins obtained by copolymerization of two or more thereof.

18

[0101] Examples of the naphthol aralkyl resins include phenol resins represented by the following Formula (XIV).

[0102]

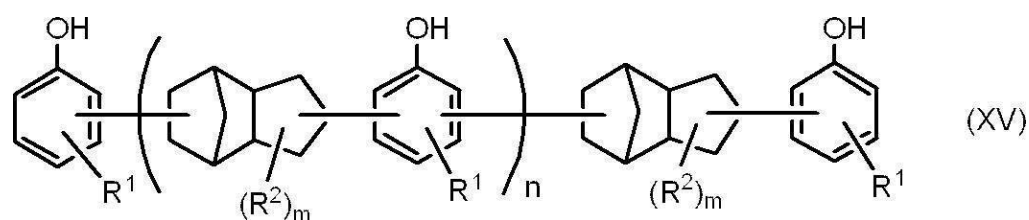


[0103] In Formula (XIV), each R^1 and R^2 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 10 carbon atoms, and n is an average value, representing a number from 0 to 10. Each of the hydrocarbon groups represented by R^1 and R^2 may independently have a substituent, or have no substituent.

[0104] Examples of the naphthol aralkyl resins represented by Formula (XIV) include compounds wherein R^1 's and R^2 's are all hydrogen atoms and, as such a compound, for example, SN-170 (trade name, manufactured by Nippon Steel & Sumikin Chemical Co., Ltd.) is available as a commercial product.

[0105] Examples of the dicyclopentadiene-type phenol resins include phenol resins represented by the following Formula (XV).

[0106]



[0107] In Formula (XV), each of R^1 and R^2 independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 10 carbon atoms; n is an average value, representing a number from 0 to 10; and m represents an integer of 0 to 6. Each of the hydrocarbon groups represented by R^1 and R^2 may independently have a substituent, or have no substituent. As a compound wherein R^1 and R^2 are hydrogen atom, for example, DPP (trade name, manufactured by Nippon Petrochemicals Co., Ltd.) is available as a commercial product.

[0108] These other curing agents may be used singly, or in combination of two or more kinds thereof. Among other curing agents that may be used in combination, novolac-type phenol resins are preferred from the standpoint of curability.

[0109] The hydroxyl equivalent of the curing agent is preferably from 100 g/eq to 199 g/eq, more preferably from 130 g/eq to 199 g/eq, still more preferably from 175 g/eq to 199 g/eq.

[0110] The hydroxyl equivalent of the curing agent is determined as follows.

The hydroxyl equivalent is determined by a pyridine-acetyl chloride method in which hydroxyl groups of the curing agent is converted into acetyl chloride in a pyridine

solution, excess reagent is subsequently degraded with water, and the resulting acetic acid is titrated with a solution containing potassium hydroxide and ethanol.

[0111] The equivalent ratio of the epoxy resin and the curing agent, namely the ratio of the number of hydroxyl groups in the curing agent with respect to the number of epoxy groups in the epoxy resin (number of hydroxyl groups in the curing agent/number of epoxy groups in the epoxy resin), is not particularly restricted; however, in order to reduce the unreacted amount of the respective components, the equivalent ratio is set in a range of preferably from 0.5 to 2, more preferably from 0.6 to 1.3. In order to obtain an epoxy resin composition having excellent moldability and reflow resistance, the equivalent ratio is more preferably set in a range of from 0.8 to 1.2.

[0112] (Curing Accelerator)

In the epoxy resin composition, from the standpoint of promoting the reaction between the epoxy resin and the curing agent, a curing accelerator may also be used as required.

As the curing accelerator, any curing accelerator that is commonly used in epoxy resin compositions can be used with no particular restriction. Examples of such a curing accelerator include cycloamidine compounds, such as 1,8-diaza-bicyclo[5.4.0]undecene-7, 1,5-diaza-bicyclo[4.3.0]nonene, and 5,6-dibutylamino-1,8-diaza-bicyclo[5.4.0]undecene-7; compounds having intramolecular polarization that are obtained by adding, to these cycloamidine compounds, a π bond-containing compound such as maleic anhydride, a quinone compound (e.g., 1,4-benzoquinone, 2,5-toluquinone, 1,4-naphthoquinone, 2,3-dimethylbenzoquinone, 2,6-dimethylbenzoquinone, 2,3-dimethoxy-5-methyl-1,4-benzoquinone, 2,3-dimethoxy-1,4-benzoquinone, or phenyl-1,4-benzoquinone), diazophenyl methane, or a phenol resin; tertiary amine compounds, such as benzyldimethylamine, triethanolamine, dimethylaminoethanol, and tris(dimethylaminomethyl)phenol; derivatives of tertiary amine compounds; imidazole compounds, such as 2-methylimidazole, 2-phenylimidazole, and 2-phenyl-4-methylimidazole; derivatives of imidazole compounds; phosphine compounds, such as tributyl phosphine, methyldiphenyl phosphine, triphenyl phosphine, tris(4-methylphenyl)phosphine, diphenyl phosphine, and phenylphosphine; phosphorous compounds having intramolecular polarization that are obtained by adding, to these phosphine compounds, a π bond-containing compound such as maleic anhydride, any of the above-described quinone compounds, diazophenylmethane, or a phenol resin; tetraphenylborates, such as tetraphenyl phosphonium tetraphenylborate, triphenylphosphine tetraphenylborate, 2-ethyl-4-methylimidazole tetraphenylborate, and *N*-methylmorpholine tetraphenylborate; and derivatives of tetraphenylborates. These curing accelerators may be used singly, or in combination of two or more kinds thereof.

[0113] Thereamong, from the standpoints of flame retardancy, curability, fluidity and mold release properties, the curing accelerator is preferably an adduct of a tertiary

phosphine compound and a quinone compound.

[0114] The tertiary phosphine compound is not particularly restricted, and examples thereof include tertiary phosphine compounds having an alkyl group or an aryl group, such as tricyclohexyl phosphine, tributyl phosphine, dibutylphenyl phosphine, butyldiphenyl phosphine, ethyldiphenyl phosphine, triphenyl phosphine, tris(4-methylphenyl)phosphine, tris(4-ethylphenyl)phosphine, tris(4-propylphenyl)phosphine, tris(4-butylphenyl)phosphine, tris(isopropylphenyl)phosphine, tris(*t*-butylphenyl)phosphine, tris(2,4-dimethylphenyl)phosphine, tris(2,6-dimethylphenyl)phosphine, tris(2,4,6-trimethylphenyl)phosphine, tris(2,6-dimethyl-4-ethoxyphenyl)phosphine, tris(4-methoxyphenyl)phosphine, and tris(4-ethoxyphenyl)phosphine.

[0115] Examples of the quinone compound include *o*-benzoquinone, *p*-benzoquinone, diphenoquinone, 1,4-naphthoquinone, and anthraquinone. Thereamong, from the standpoints of moisture resistance and storage stability, the quinone compound is preferably *p*-benzoquinone.

[0116] As the curing accelerator, an adduct of triphenyl phosphine and *p*-benzoquinone is preferred from the standpoint of reflow resistance, and an adduct of tris(4-methylphenyl)phosphine and *p*-benzoquinone is preferred from the standpoint of mold release properties.

[0117] The content ratio of the curing accelerator is not particularly restricted as long as a curing acceleration effect can be attained. When the epoxy resin composition contains a curing accelerator, the content ratio thereof is preferably from 0.005% by mass to 2% by mass, more preferably from 0.01% by mass to 0.5% by mass. A content ratio of 0.005% by mass or higher tends to improve the curability, while a content ratio of 2% by mass or less tends to improve the pot life.

[0118] (Inorganic Filler)

The epoxy resin composition may further include an inorganic filler. Incorporation of an inorganic filler tends to reduce the hygroscopicity and the linear expansion coefficient and to improve the thermal conductivity and the strength. Examples of the inorganic filler include powders of fused silica, crystalline silica, alumina, zircon, calcium silicate, calcium carbonate, potassium titanate, silicon carbide, silicon nitride, aluminum nitride, boron nitride, beryllia, zirconia, zircon, forsterite, steatite, spinel, mullite, titania and the like; and beads obtained by spheronization of these powders; and glass fibers. Further, examples of an inorganic filler having a flame retardant effect include aluminum hydroxide, magnesium hydroxide, complex metal hydroxide, zinc borate, and zinc molybdate. As zinc borate, for example, FB-290 and FB-500 (U.S. Borax Inc.) and FRZ-500C (Mizusawa Industrial Chemicals, Ltd.) are available as commercial products and, as zinc molybdate, for example, KEMGARD 911B, 911C and 1100 (Sherwin-Williams Co.) are available as commercial products.

[0119] These inorganic fillers may be used singly, or in combination of two or more kinds

thereof. Thereamong, fused silica is preferred from the standpoints of filling properties and reduction in linear expansion coefficient, and alumina is preferred from the standpoint of high thermal conductivity. The shape of the inorganic filler is preferably spherical from the standpoints of filling properties and mold abrasion.

[0120] The average particle size of the inorganic filler is preferably from 1 μm to 50 μm , more preferably from 10 μm to 30 μm . When the average particle size is 1 μm or larger, an increase in the viscosity of the epoxy resin composition tends to be suppressed, whereas when the average particle size is 50 μm or smaller, preferably 30 μm or smaller, filling into narrow gaps tends to be improved. The average particle size of the inorganic filler is measured as volume-average particle size using a laser diffraction-scattering particle size distribution analyzer.

[0121] The specific surface area of the inorganic filler is, from the standpoints of flame retardancy and fluidity, preferably from 1 m^2/g to 5 m^2/g , more preferably from 2 m^2/g to 4 m^2/g .

[0122] When the epoxy resin composition includes such an inorganic filler, the content ratio of the inorganic filler in the epoxy resin composition is preferably not less than 50% by mass from the standpoints of fluidity, flame retardancy, moldability, reduction in hygroscopicity, reduction in linear expansion coefficient, improvement of the strength, and reflow resistance, more preferably from 60% by mass to 95% by mass from the standpoint of flame retardancy, still more preferably from 70% by mass to 90% by mass. When the content ratio of the inorganic filler is 50% by mass or higher, the fluidity tends to be improved, whereas when the content ratio is 95% by mass or less, the flame retardancy and the reflow resistance tend to be improved.

[0123] (Coupling Agent)

The epoxy resin composition may further include a coupling agent. When an inorganic filler is used in the epoxy resin composition, the coupling agent tends to improve the adhesion between the resin component and the inorganic filler. As the coupling agent, any coupling agent that is commonly used in epoxy resin compositions can be used with no particular restriction. Examples of such a coupling agent include silane compounds having a primary, secondary or tertiary amino group; various silane compounds, such as epoxysilane, mercaptosilane, alkylsilane, ureido silane, and vinyl silane; titanium compounds; aluminum chelate compounds; and compounds containing aluminum and zirconium.

[0124] Examples of the coupling agent also include silane coupling agents, such as vinyltrichlorosilane, vinyltriethoxysilane, vinyltris(β -methoxyethoxy)silane, γ -methacryloxypropyltrimethoxysilane, β -(3,4-epoxycyclohexyl)ethyltrimethoxysilane, γ -glycidoxypropyltrimethoxysilane, γ -glycidoxypropylmethyldimethoxysilane, vinyltriacetoxysilane, γ -mercaptopropyltrimethoxysilane, γ -aminopropyltrimethoxysilane, γ -aminopropylmethyldimethoxysilane, γ -aminopropyltriethoxysilane,

γ -aminopropylmethyldiethoxysilane, γ -anilinopropyltrimethoxysilane,
 γ -anilinopropyltriethoxysilane, γ -(*N,N*-dimethyl)aminopropyltrimethoxysilane,
 γ -(*N,N*-diethyl)aminopropyltrimethoxysilane, γ -(*N,N*-dibutyl)aminopropyltrimethoxysilane,
 γ -(*N*-methyl)anilinopropyltrimethoxysilane, γ -(*N*-ethyl)anilinopropyltrimethoxysilane,
 γ -(*N,N*-dimethyl)aminopropyltriethoxysilane, γ -(*N,N*-diethyl)aminopropyltriethoxysilane,
 γ -(*N,N*-dibutyl)aminopropyltriethoxysilane, γ -(*N*-methyl)anilinopropyltriethoxysilane,
 γ -(*N*-ethyl)anilinopropyltriethoxysilane,
 γ -(*N,N*-dimethyl)aminopropylmethyldimethoxysilane,
 γ -(*N,N*-diethyl)aminopropylmethyldimethoxysilane,
 γ -(*N,N*-dibutyl)aminopropylmethyldimethoxysilane,
 γ -(*N*-methyl)anilinopropylmethyldimethoxysilane,
 γ -(*N*-ethyl)anilinopropylmethyldimethoxysilane, *N*-(trimethoxysilylpropyl)ethylene
diamine, *N*-(dimethoxymethylsilylisopropyl)ethylene diamine, methyltrimethoxysilane,
dimethyldimethoxysilane, methyltriethoxysilane, γ -chloropropyltrimethoxysilane,
hexamethyldisilane, vinyltrimethoxysilane, and γ -mercaptopropylmethyldimethoxysilane;
and titanate coupling agents, such as isopropyl triisostearoyl titanate, isopropyl tris(dioctyl
pyrophosphate)titanate, isopropyl tris(*N*-aminoethyl-aminoethyl)titanate, tetraoctyl
bis(ditridecyl phosphite)titanate, tetra(2,2-diallyloxymethyl-1-butyl)bis(ditridecyl
phosphite)titanate, bis(dioctyl pyrophosphate)oxyacetate titanate, bis(dioctyl
pyrophosphate)ethylene titanate, isopropyl trioctanoyl titanate, isopropyl
dimethacrylisostearoyl titanate, isopropyl tridodecylbenzenesulfonyl titanate, isopropyl
isostearoyldiacryl titanate, isopropyl tri(dioctyl phosphate)titanate, isopropyl
tricumylphenyl titanate, and tetraisopropyl bis(dioctyl phosphite)titanate. These coupling
agents may be used singly, or in combination of two or more kinds thereof.

[0125] Thereamong, from the standpoints of fluidity, reduction of gold wire deformation, and flame retardancy, the coupling agent is preferably a silane coupling agent having a secondary amino group. The silane coupling agent having a secondary amino group is not particularly restricted as long as it is a silane compound having a secondary amino group in the molecule.

[0126] Examples of the silane coupling agent having a secondary amino group include
 γ -anilinopropyltrimethoxysilane, γ -anilinopropyltriethoxysilane,
 γ -anilinopropylmethyldimethoxysilane, γ -anilinopropylmethyldiethoxysilane,
 γ -anilinopropylethyldiethoxysilane, γ -anilinopropylethyldimethoxysilane,
 γ -anilinomethyltrimethoxysilane, γ -anilinomethyltriethoxysilane,
 γ -anilinomethylmethyldimethoxysilane, γ -anilinomethylmethyldiethoxysilane,
 γ -anilinomethylethyldiethoxysilane, γ -anilinomethylethyldimethoxysilane,
N-(*p*-methoxyphenyl)- γ -aminopropyltrimethoxysilane,
N-(*p*-methoxyphenyl)- γ -aminopropyltriethoxysilane,
N-(*p*-methoxyphenyl)- γ -aminopropylmethyldimethoxysilane,

N-(*p*-methoxyphenyl)- γ -aminopropylmethyldiethoxysilane,
N-(*p*-methoxyphenyl)- γ -aminopropylethyldiethoxysilane,
N-(*p*-methoxyphenyl)- γ -aminopropylethyldimethoxysilane,
 γ -(*N*-methyl)aminopropyltrimethoxysilane, γ -(*N*-ethyl)aminopropyltrimethoxysilane,
 γ -(*N*-butyl)aminopropyltrimethoxysilane, γ -(*N*-benzyl)aminopropyltrimethoxysilane,
 γ -(*N*-methyl)aminopropyltriethoxysilane, γ -(*N*-ethyl)aminopropyltriethoxysilane,
 γ -(*N*-butyl)aminopropyltriethoxysilane, γ -(*N*-benzyl)aminopropyltriethoxysilane,
 γ -(*N*-methyl)aminopropylmethyldimethoxysilane,
 γ -(*N*-ethyl)aminopropylmethyldimethoxysilane,
 γ -(*N*-butyl)aminopropylmethyldimethoxysilane,
 γ -(*N*-benzyl)aminopropylmethyldimethoxysilane,
N- β -(aminoethyl)- γ -aminopropyltrimethoxysilane,
 γ -(β -aminoethyl)aminopropyltrimethoxysilane, and
N- β -(*N*-vinylbenzylaminoethyl)- γ -aminopropyltrimethoxysilane.

[0127] When the epoxy resin composition contains a coupling agent, the content ratio of the coupling agent in the epoxy resin composition is preferably from 0.037% by mass to 5% by mass, more preferably from 0.05% by mass to 4.75% by mass, still more preferably from 0.1% by mass to 2.5% by mass. When the content ratio is 0.037% by mass or higher, the adhesion with a frame is improved, whereas when the content ratio is 5% by mass or less, the curability is improved.

[0128] (Flame Retardant)

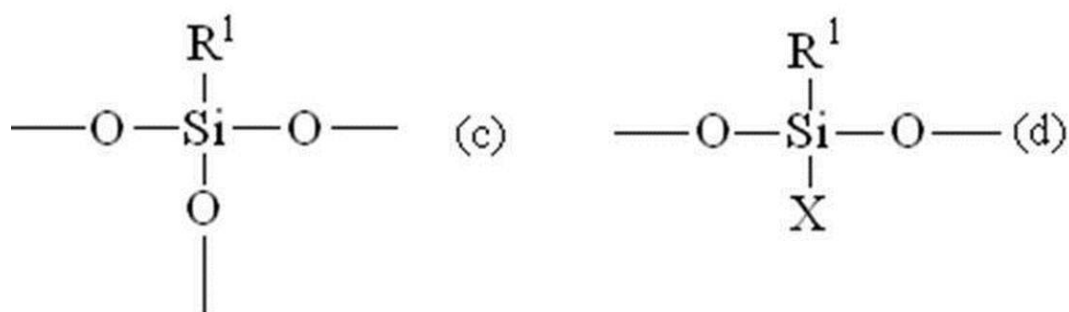
The epoxy resin composition may further include, as required, any conventionally known flame retardant from the standpoint of improving the flame retardancy, particularly a non-halogen and non-antimony flame retardant from the standpoint point of environmental friendliness and reliability. Examples of such a flame retardant include inorganic compounds, such as red phosphorus, phosphates, and zinc oxide; red phosphorus coated with a thermosetting resin (e.g., phenol resin); resin-coated phosphorus compounds, such as phosphine oxide; nitrogen-containing compounds, such as melamine, melamine derivatives, melamine-modified phenol resins, triazine ring-containing compounds, cyanuric acid derivatives, and isocyanuric acid derivatives; phosphorus and nitrogen-containing compounds, such as cyclophosphazene; and metal element-containing compounds, such as aluminum hydroxide, magnesium hydroxide, complex metal hydroxides, zinc oxide, zinc stannate, zinc borate, iron oxide, molybdenum oxide, zinc molybdate, and dicyclopentadienyl iron. These flame retardants may be used singly, or in combination of two or more kinds thereof.

[0129] (Silicon-Containing Polymer)

From the standpoint of reducing warpage, the epoxy resin composition may further contain a silicon-containing polymer. The silicon-containing polymer is preferably a compound which contains the following bonds (c) and (d) and a group selected from the

group consisting of R¹, a hydroxyl group and an alkoxy group at a terminal and has an epoxy equivalent of from 500 g/eq to 4,000 g/eq. Examples of the silicon-containing polymer include branched polysiloxanes called "silicone resins".

[0130]



[0131] In these bonds (c) and (d), each R¹ independently represents a monovalent hydrocarbon group having from 1 to 12 carbon atoms, and X represents an epoxy group-containing monovalent organic group. Each of the hydrocarbon groups represented by R¹ may independently have a substituent, or have no substituent. The epoxy group contained in X may undergo a ring-opening reaction to convert X into a divalent group.

[0132] Examples of R¹ in the bonds (c) and (d) include alkyl groups, such as a methyl group, an ethyl group, a propyl group, a butyl group, an isopropyl group, an isobutyl group, a *t*-butyl group, a pentyl group, a hexyl group, a heptyl group, an octyl group, and a 2-ethylhexyl group; alkenyl groups, such as a vinyl group, an allyl group, a butenyl group, a pentenyl group, and a hexenyl group; aryl groups, such as a phenyl group, a tolyl group, a xylyl group, a naphthyl group, and a biphenyl group; and aralkyl groups, such as a benzyl group and a phenethyl group, among which a methyl group or a phenyl group is preferred.

[0133] In the bond (d), X is an epoxy group-containing monovalent organic group. In this organic group, the binding position of the epoxy group is not particularly restricted, and the epoxy group is preferably bound to a terminal of the organic group.

[0134] Specific examples of X include a 2,3-epoxypropyl group, a 3,4-epoxybutyl group, a 4,5-epoxypentyl group, a 2-glycidoxyethyl group, a 3-glycidoxypropyl group, a 4-glycidoxybutyl group, a 2-(3,4-epoxycyclohexyl)ethyl group, and a 3-(3,4-epoxycyclohexyl)propyl group, among which a 3-glycidoxypropyl group is preferred.

[0135] At a terminal of the silicon-containing polymer, from the standpoint of the storage stability of the polymer, it is preferred that each R¹ is independently a hydroxyl group or an alkoxy group. Examples of the alkoxy group as a terminal include a methoxy group, an ethoxy group, a propoxy group, and a butoxy group.

[0136] In cases where the silicon-containing polymer has an epoxy group, the epoxy equivalent is in a range of preferably from 500 g/eq to 4,000 g/eq, more preferably from 1,000 g/eq to 2,500 g/eq. When the epoxy equivalent of the silicon-containing polymer is 500 g/eq or higher, the fluidity of the epoxy resin composition tends to be improved,

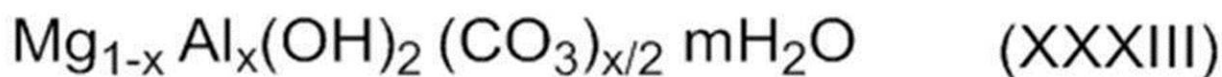
whereas when the epoxy equivalent is 4,000 g/eq or less, bleeding on the surface of a cured product is suppressed, so that the occurrence of molding defects tends to be reduced.

[0137] In cases where the epoxy resin composition includes a silicon-containing polymer, the content ratio of the silicon-containing polymer in the epoxy resin composition is preferably from 0.2% by mass to 1.5% by mass, more preferably from 0.3% by mass to 1.3% by mass. When the content ratio is 0.2% by mass or higher, the package warpage-reducing effect tends to be improved, whereas when the content ratio is 1.5% by mass or less, the curability tends to be improved.

[0138] (Other Components)

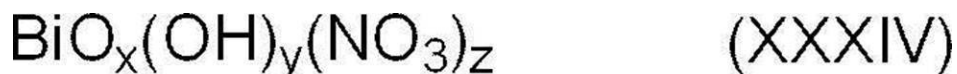
From the standpoint of improving the moisture resistance and the high-temperature storage performance of a semiconductor element such as an IC, the epoxy resin composition may also include, as required, at least one selected from the group consisting of compounds represented by the following Formula (XXXIII) and compounds represented by the following Formula (XXXIV).

[0139]



($0 < x \leq 0.5$, m is a positive number)

[0140]



($0.9 \leq x \leq 1.1$, $0.6 \leq y \leq 0.8$, $0.2 \leq z \leq 0.4$)

[0141] As a commercial product of a compound represented by Formula (XXXIII), DHT-4A (trade name, manufactured by Kyowa Chemical Industry Co., Ltd.) is available. Further, as a commercial product of a compound represented by Formula (XXXIV), IXE500 (trade name, manufactured by Toagosei Co., Ltd.) is available. As required, other anion exchanger may be added as well. The anion exchanger is not particularly restricted, and any conventionally known anion exchanger, examples of which include hydrous oxides of elements such as magnesium, aluminum, titanium, zirconium, and antimony, can be used. These anion exchangers may be used singly, or in combination of two or more kinds thereof.

[0142] Furthermore, in the epoxy resin composition, other additives such as a mold release agent (e.g., a higher fatty acid, a higher fatty acid metal salt, an ester wax, a polyolefin wax, a polyethylene, and a polyethylene oxide), a colorant (e.g., carbon black), and a stress relaxation agent (e.g., a silicone oil and a silicone rubber powder) may also be incorporated as required.

[0143] <Method of Preparing Epoxy Resin Composition>

The epoxy resin composition may be prepared by any method as long as various

raw materials can be uniformly dispersed and mixed. Examples of a general preparation method include a method in which raw materials each in a prescribed amount are thoroughly mixed using a mixer or the like and subsequently further mixed or melt-kneaded using a mixing roll, an extruder, a grinder, a planetary mixer or the like, after which the resultant is cooled and, as required, degassed and pulverized. Further, as required, the resulting epoxy resin composition may be made into a tablet having dimensions and mass that conform to the molding conditions.

[0144] <Electronic Component Device>

The electronic component device according to one embodiment of the invention includes: an element; and a cured product of the above-described epoxy resin composition, which seals the element. A low-pressure transfer molding method is generally employed as a method of sealing the element with the epoxy resin composition of the present embodiment as a sealing material; however, for example, an injection molding method or a compression molding method may be employed as well. As a method of providing the epoxy resin composition, for example, a dispensing method, a casting method, or a printing method may be employed.

[0145] Examples of the electronic component device of the present embodiment that includes an element sealed with the epoxy resin composition of the present embodiment include electronic component devices in which an element, such as an active element (e.g., a semiconductor chip, a transistor, a diode, or a thyristor) or a passive element (e.g., a capacitor, a resistor, or a coil) is mounted on a support member, a mounting substrate or the like, such as a lead frame, a wired tape carrier, a wiring board, a glass plate or a silicone wafer, and desired parts thereof are sealed with the epoxy resin composition of the present embodiment.

[0146] The mounting substrate is not particularly restricted, and examples thereof include interposer substrates, such as organic substrates, organic films, ceramic substrates, and glass substrates, liquid crystal glass substrates, MCM (Multi-Chip Module) substrates, and hybrid IC substrates.

[0147] Examples of such electronic component devices having an element include semiconductor devices, specifically resin-sealed ICs which are obtained by immobilizing an element (e.g., a semiconductor chip) on a lead frame (island or tab), connecting a terminal portion of an element (e.g., a bonding pad) and a lead portion by wire bonding or bumping, and then sealing the resultant with the epoxy resin composition of the present embodiment by transfer molding or the like, such as DIPs (Dual Inline Packages), PLCCs (Plastic Leaded Chip Carriers), QFPs (Quad Flat Packages), SOPs (Small Outline Packages), SOJs (Small Outline J-lead Packages), TSOPs (Thin Small Outline Packages), and TQFPs (Thin Quad Flat Packages); TCPs (Tape Carrier Packages) which are obtained by sealing, with the epoxy resin composition of the present embodiment, a semiconductor chip lead-bonded to a tape carrier; semiconductor devices on which a bare chip is mounted,

such as COBs (Chip On Boards) and COGs (Chip On Glass), that are obtained by sealing, with the epoxy resin composition of the present embodiment, a semiconductor chip connected to a wiring formed on a wiring board or a glass plate by wire bonding, flip-chip bonding, soldering or the like; hybrid ICs which are obtained by sealing, with the epoxy resin composition of the present embodiment, an active element (e.g., a semiconductor chip, a transistor, a diode, or a thyristor), a passive element (e.g., a capacitor, a resistor, or a coil) or the like connected to a wiring formed on a wiring board or a glass plate by wire bonding, flip-chip bonding, soldering or the like; and BGAs (Ball Grid Arrays), CSPs (Chip Size Packages) and MCPs (Multi-Chip Packages) which are obtained by mounting a semiconductor chip on an interposer substrate having a terminal for connection with an MCM (Multi-Chip Module) mother board, connecting the semiconductor chip with a wiring formed on the interposer substrate by bumping or wire bonding, and then sealing the semiconductor chip-mounted side with the epoxy resin composition of the present embodiment. These semiconductor devices may be stacked (laminated)-type packages in which two or more elements are mounted on a mounting substrate in layers, or simultaneously molded-type packages in which two or more elements are all sealed at once with an epoxy resin composition.

EXAMPLES

[0148] The present invention will now be described by way of Synthesis Examples and Examples thereof; however, the scope of the present invention is not restricted thereto.

[0149] [Synthesis Examples 1 to 4]

The specific epoxy resin can be synthesized as follows.

First, a specific phenol novolac resin was obtained by allowing a raw material phenol novolac resin to react with a raw material benzyl group-containing compound using *p*-toluenesulfonic acid as an acid catalyst. At this point, the hydroxyl equivalent was measured in the same manner as in the above-described method of measuring the hydroxyl equivalent in a curing agent, and the value of *p* in Formula (1) was determined from the thus measured value.

Then, the thus obtained specific phenol novolac resin was epoxidized with epichlorohydrin. The epoxy equivalent, the softening point and the melt viscosity at 150°C of the resulting resin are shown in Table 1 below. It is noted here that, in the thus obtained specific epoxy resin, R₂ in Formula (1) was a benzyl group (R₃ was a hydrogen atom).

[0150] [Table 1]

Resin properties	Synthesis Examples			
	1	2	3	4
p	0.6	0.9	1.0	1.1
Epoxy equivalent (g/eq)	240	263	264	265
Softening point (°C)	55	58	60	61
Melt viscosity (Pa·s) (150°C)	0.08	0.10	0.11	0.12

[0151] [Examples 1 to 4 and Comparative Examples 1 to 8]

The below-described components were blended in the respective amounts (parts by mass) shown in Tables 2 and 3 and subsequently roll-kneaded at a kneading temperature of 80°C for a kneading time of 10 minutes, whereby epoxy resin compositions of Examples 1 to 4 and Comparative Examples 1 to 8 were prepared.

[0152] (Epoxy Resins)

- epoxy resin 1: epoxy equivalent = 240 g/eq, softening point = 55°C, an epoxy resin which is a compound represented by Formula (1) wherein p = 0.6
- epoxy resin 2: epoxy equivalent = 263 g/eq, softening point = 58°C, an epoxy resin which is a compound represented by Formula (1) wherein p = 0.9
- epoxy resin 3: epoxy equivalent = 264 g/eq, softening point = 60°C, an epoxy resin which is a compound represented by Formula (1) wherein p = 1.0
- epoxy resin 4: epoxy equivalent = 265 g/eq, softening point = 61°C, an epoxy resin which is a compound represented by Formula (1) wherein p = 1.1
- epoxy resin 5: epoxy equivalent = 251 g/eq, softening point = 60°C, a copolymer of 2-methoxynaphthalene and an *o*-cresol novolac-type epoxy resin (trade name: HP-5000, manufactured by DIC Corporation)
- epoxy resin 6: epoxy equivalent = 190 g/eq, melting point = 59°C, an *o*-cresol novolac-type epoxy resin (trade name: N-500P-1, manufactured by DIC Corporation)

[0153] (Curing Agents)

- curing agent 1: a phenol aralkyl resin having a hydroxyl equivalent of 175 g/eq and a softening point of 70°C (trade name: MEH-7800SS, manufactured by Meiwa Plastic Industries, Ltd.)
- curing agent 2: a novolac-type phenol resin having a hydroxyl equivalent of 106 g/eq and a softening point of 82°C (trade name: HP-850N, manufactured by Hitachi Chemical Co., Ltd.)

[0154] (Curing Accelerator)

- curing accelerator 1: an adduct of triphenyl phosphine and 1,4-benzoquinone

[0155] (Coupling Agent)

- epoxysilane: γ -glycidoxypolytrimethoxysilane

[0156] (Inorganic Filler)

- spherical fused silica: average particle size = 14.5 μm , specific surface area = 2.8 m^2/g

[0157] (Other Additives)

- carnauba wax (manufactured by Clariant K.K.)
- carbon black (manufactured by Mitsubishi Chemical Corporation, trade name: MA-600)

[0158] [Table 2]

Blended components	Examples				Comparative Examples			
	1	2	3	4	1	2	3	4
Epoxy resin 1	100				100			
Epoxy resin 2		100				100		
Epoxy resin 3			100				100	
Epoxy resin 4				100				100
Epoxy resin 5								
Epoxy resin 6								
Curing agent 1	73	67	66	66				
Curing agent 2					44	40	40	40
Curing accelerator 1	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
Epoxy silane	4.0	4.0	4.0	4.0	4.0	4.0	4.0	4.0
Carnauba wax	2.0	2.0	2.0	2.0	2.0	2.0	2.0	2.0
Carbon black	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
Fused silica	1,220	1,182	1,182	1,157	1,032	1,009	1,009	994
Amount of filler (% by mass)	87	87	87	87	87	87	87	87

[0159] [Table 3]

Blended components	Comparative Examples			
	5	6	7	8
Epoxy resin 1				
Epoxy resin 2				
Epoxy resin 3				
Epoxy resin 4				
Epoxy resin 5	100		100	
Epoxy resin 6		100		100
Curing agent 1	70	92		
Curing agent 2			42	56
Curing accelerator 1	3.0	3.0	3.0	3.0
Epoxy silane	4.0	4.0	4.0	4.0
Carnauba wax	2.0	2.0	2.0	2.0
Carbon black	2.5	2.5	2.5	2.5
Fused silica	1,208	1,357	1,025	1,115
Amount of filler (% by mass)	87	87	87	87

[0160] The properties of the thus prepared epoxy resin compositions of Examples 1 to 4 and Comparative Examples 1 to 8 were determined by the following tests. The results thereof are shown in Tables 4 and 5.

[0161] (1) Spiral Flow (Fluidity Index)

Using a mold for spiral flow measurement according to EMMI-1-66, each epoxy resin composition was molded by a transfer molding machine under the conditions of a mold temperature of 180°C, a molding pressure of 6.9 MPa, and a curing time of 90 seconds to determine the flow distance (cm).

[0162] (2) Hot Hardness

Each epoxy resin composition was molded into a circular disk of 50 mm in diameter and 3 mm in thickness under the above-described molding conditions of (1) and, immediately thereafter, the hardness was measured using a Shore D-type hardness meter.

[0163] (3) Flame Retardancy

Using a mold for molding a test piece of 1/32 inch (0.8 mm) in thickness, each epoxy resin composition was molded under the above-described molding conditions of (1), and the resultant was post-cured at 180°C for 5 hours, after which the flame retardancy was evaluated in accordance with the UL-94 test method.

[0164] (4) Reflow Resistance

(4.1) Cu Lead Frame

An 80-pin flat package (QFP) having external dimensions of 20 mm × 14 mm × 2 mm (lead frame material: copper alloy, the die pad upper surface and the lead tip were

plated with silver), which was equipped with an 8 mm × 10 mm × 0.4 mm silicon chip, was prepared by molding and post-curing each epoxy resin composition under the above-described conditions of (3), and subsequently moistened under the conditions of 85°C and 85% RH. After a prescribed time, the package was subjected to a reflow treatment at 240°C for 10 seconds, and the presence or absence of cracks was visually observed to evaluate the reflow resistance in terms of the number of packages with cracks relative to the number of tested packages (five).

[0165] (4.2) PPF Lead Frame

The reflow resistance was evaluated in the same manner as in (4.1), except that a PPF (core material: copper alloy, plated in three layers (Ni/Pd/Au)) was used as the lead frame.

[0166] (5) Moisture Resistance

An 80-pin flat package (QFP) having external dimensions of 20 mm × 14 mm × 2.7 mm, which was equipped with a 6 mm × 6 mm × 0.4 mm test silicon chip having an aluminum wiring of 10 μm in line width and 1 μm in thickness on a 5 μm-thick silicon oxide film, was prepared by molding and post-curing each epoxy resin composition under the above-described conditions of (3), and subsequently pre-treated and then moistened. After a prescribed time, disconnection defects caused by corrosion of the aluminum wiring were examined, and the moisture resistance was evaluated in terms of the number of defective packages relative to the number of tested packages (ten).

[0167] It is noted here that, as the pre-treatment, after each flat package was moistened under the conditions of 85°C and 85% RH for 72 hours, a vapor-phase reflow treatment was performed at 215°C for 90 seconds. The subsequent moistening was performed under the conditions of 0.2 MPa and 121°C.

[0168] (6) High-Temperature Storage Performance

A 16 pin-type DIP (Dual Inline Package), in which 5 mm × 9 mm × 0.4 mm test silicon chip having an aluminum wiring of 10 μm in line width and 1 μm in thickness on a 5 μm-thick silicon oxide film was mounted on a partially silver-plated lead frame of 42 alloy with a silver paste and the bonding pad of the chip and an inner lead were connected via an Au wire at 200°C using a thermosonic wire bonder, was prepared by molding and post-curing each epoxy resin composition under the above-described conditions of (3), and store in a 200°C high-temperature chamber. After a prescribed time, the DIP was taken out, and a continuity test was performed to evaluate the high-temperature storage performance in terms of the number of packages with continuity defects relative to the number of tested packages (ten).

[0169] [Table 4]

Properties		Examples				Comparative Examples			
		1	2	3	4	1	2	3	4
Flame retardancy: after-flame time (s)		35	33	30	33	32	40	42	41
Evaluation		V-0	V-0	V-0	V-0	V-0	V-0	V-0	V-0
Spiral flow (cm)		108	118	117	115	76	79	79	80
Hot hardness (Shore D)		83	82	81	81	85	84	83	82
Reflow resistance	48 h	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5
Cu lead frame	72 h	0/5	0/5	0/5	0/5	1/5	0/5	0/5	0/5
	96 h	0/5	0/5	0/5	0/5	2/5	1/5	1/5	1/5
	168 h	2/5	1/5	1/5	0/5	5/5	2/5	3/5	1/5
Reflow resistance	48 h	0/5	0/5	0/5	0/5	0/5	0/5	0/5	0/5
PPF lead frame	72 h	1/5	0/5	0/5	0/5	2/5	0/5	0/5	0/5
	96 h	3/5	2/5	0/5	0/5	4/5	0/5	0/5	0/5
	168 h	5/5	5/5	5/5	5/5	4/5	4/5	3/5	4/5
Moisture resistance	100 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
	500 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
	1,000 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
	1,500 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
	2,000 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
	3,000 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
High-temperature	500 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
storage performance	1,000 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
	1,500 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10
	2,000 h	0/10	0/10	0/10	0/10	0/10	0/10	0/10	0/10

[0170] [Table 5]

Properties		Comparative Examples			
		5	6	7	8
Flame retardancy: after-flame time (s)		40	42	42	75
Evaluation		V-0	V-1	V-0	V-1
Spiral flow (cm)		118	117	79	76
Hot hardness (Shore D)		76	80	77	83
Reflow resistance	48 h	0/5	0/5	0/5	0/5
Cu lead frame	72 h	0/5	1/5	1/5	2/5
	96 h	0/5	2/5	2/5	3/5
	168 h	2/5	5/5	5/5	5/5
Reflow resistance	48 h	0/5	1/5	0/5	2/5
PPF lead frame	72 h	2/5	3/5	2/5	4/5
	96 h	3/5	4/5	4/5	4/5
	168 h	5/5	5/5	5/5	5/5
Moisture resistance	100 h	0/10	0/10	0/10	0/10
	500 h	0/10	0/10	0/10	0/10
	1,000 h	0/10	0/10	0/10	0/10
	1,500 h	0/10	0/10	0/10	0/10
	2,000 h	0/10	0/10	0/10	0/10
	3,000 h	0/10	0/10	0/10	0/10
High-temperature storage performance	500 h	0/10	0/10	0/10	0/10
	1,000 h	0/10	0/10	0/10	0/10
	1,500 h	0/10	0/10	0/10	0/10
	2,000 h	0/10	0/10	0/10	0/10

[0171] In Comparative Examples 5 and 7 where a compound represented by Formula (1) was not incorporated, the moldability was poor due to low hot hardness. In Comparative Examples 6 and 8, the reflow resistance was poor, and a flame retardancy of V-0 was not achieved.

In Comparative Examples 1 to 4 where a specific curing agent was not used, the spiral flow was smaller and the moldability was inferior as compared to Examples 1 to 4. Further, as compared to Examples 1 to 4 using a specific curing agent, the reflow resistance in the Cu lead frame (particularly at 72 h and 96 h) was slightly lower in Comparative Examples 1 to 4 where a specific curing agent was not used.

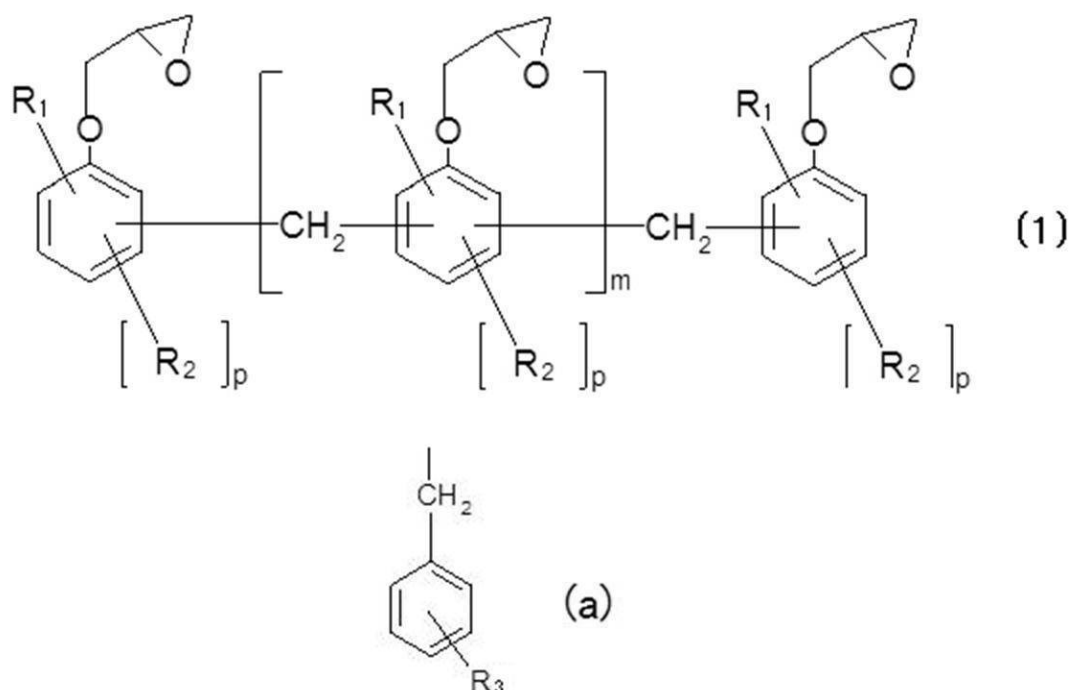
[0172] On the other hand, the epoxy resin compositions of Examples 1 to 4, which contained a compound represented by Formula (1), all had favorable fluidity and reflow resistance, achieved a UL-94 flame retardancy of V-0, and exhibited favorable flame retardancy and moldability.

[0173] The disclosure of Japanese Patent Application No. 2016-091768 filed on April 28, 2016, is hereby incorporated by reference in its entirety.

All the documents, patent applications and technical standards that are described in the present specification are hereby incorporated by reference to the same extent as if each individual document, patent application or technical standard is concretely and individually described to be incorporated by reference.

CLAIMS

1. An epoxy resin composition comprising:
an epoxy resin containing a compound represented by the following Formula (1);
and
a curing agent containing at least one selected from the group consisting of
biphenylene-type phenol aralkyl resins, phenol aralkyl resins and triphenylmethane-type
phenol resins:



wherein, in Formula (1), each R₁ independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms; each R₂ represents a substituent represented by Formula (a); m represents a number from 0 to 20; p represents from 0.5 to 2.0; and each R₃ independently represents a hydrogen atom or a monovalent hydrocarbon group having from 1 to 6 carbon atoms.

2. The epoxy resin composition according to claim 1, further comprising a curing accelerator.
3. The epoxy resin composition according to claim 2, wherein the curing accelerator comprises an adduct of a tertiary phosphine compound and a quinone compound.
4. The epoxy resin composition according to any one of claims 1 to 3, further

comprising an inorganic filler.

5. The epoxy resin composition according to claim 4, wherein a content ratio of the inorganic filler is from 60% by mass to 95% by mass.

6. The epoxy resin composition according to any one of claims 1 to 5, further comprising a coupling agent.

7. The epoxy resin composition according to claim 6, wherein the coupling agent comprises a secondary amino group-containing silane coupling agent.

8. An electronic component device comprising:
an element; and
a cured product of the epoxy resin composition according to any one of claims 1 to 7, which seals the element.