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(19) **United States**(12) **Patent Application Publication****Noro et al.**(10) **Pub. No.: US 2009/0182091 A1**(43) **Pub. Date: Jul. 16, 2009**(54) **CURABLE COMPOSITION**

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C08L 83/04 (2006.01)(52) **U.S. Cl.** **524/588**(57) **ABSTRACT**

The present invention has its object to provide a curable composition which comprises a guanidine compound as a non-organotin type catalyst, is less discolored, has good surface curability, depth curability, strength rise and adhesiveness, and can retain the curability even after storage; the above object can be achieved by a curable composition which comprises: (A) an organic polymer containing a silyl group capable of crosslinking under siloxane bond formation, the silyl group being a group represented by the general formula (1): —SiX_3 (1) (wherein X represents a hydroxyl group or a hydrolyzable group and the three X groups may be mutually the same or different), (B) a guanidine compound (B-1) as a silanol condensation catalyst, and (C) a plasticizer, wherein the content of the component (B-1) is not lower than 0.1 part by weight but lower than 8 parts by weight per 100 parts by weight of the component (A), and a non-phthalate ester plasticizer accounts for 80 to 100% by weight of the (C) component plasticizer.

CURABLE COMPOSITION

TECHNICAL FIELD

[0001] The present invention relates to a curable composition which comprises an organic polymer containing a silicon atom-bound hydroxyl or hydrolyzable group and containing a silyl group capable of crosslinking under siloxane bond formation (hereinafter referred to as a "reactive silyl group").

BACKGROUND ART

[0002] It is known that organic polymers containing at least one reactive silyl group in the molecule have properties such that they are crosslinked under siloxane bond formation resulting from hydrolysis and other reactions of the reactive silyl group due to moisture and the like, even at room temperature to give rubber-like cured products.

[0003] Among these reactive silyl group-containing organic polymers, those polymers which have a polyoxyalkylene type or polyisobutylene type main chain skeleton are disclosed in Patent Document 1, Patent Document 2 and the like and have already been produced industrially and are in wide use in such fields as sealants, adhesives and coatings.

[0004] Since moisture in the air causes curing of curable compositions comprising such reactive silyl group-containing organic polymers, a great difference tends to arise between the curability of the composition inside (depth curability) and the surface curability. In particular, in the case of one-pack type curable compositions obtained by dehydration, a marked difference tends to arise between depth curability and surface curability. Further, compositions having good depth curability tend to show rapid increase in initial strength (to reach high strength in a short period of time). Generally desired are curable compositions showing rapid curability in the depths and rapid increase in initial strength.

[0005] For obtaining cured products from the curable composition comprising a reactive silyl group-containing organic polymer, a silanol condensation catalyst is used. Generally used as the silanol condensation catalyst are organotin type catalysts having a carbon-tin bond such as dibutyltin bis (acetylacetonate), since they render the composition excellent in both surface curability and depth curability simultaneously and also cause rapid increase in initial strength of cured products obtained.

[0006] In recent years, however, the toxicity of organotin type compounds have been pointed out and development of non-organotin catalysts has been looked for.

[0007] Patent Document 3, Patent Document 4, Patent Document 5, Patent Document 6 and Patent Document 7 disclose carboxylic acid tin salts and other carboxylic acid metal salts as silanol condensation catalysts. Further, it is disclosed that the addition of an amine compound, as a promoter, to these catalysts results in improvements in curability. However, from the environmental stress viewpoint, substantially metal-free silanol condensation catalysts are desired and, Patent Document 8 discloses that the combined use of an amine compound and a carboxylic acid can provide metal-free silanol condensation catalysts.

[0008] However, curable compositions using the non-organotin type silanol catalysts described in the above-cited patent documents are sometimes insufficient in surface curability and adhesiveness.

[0009] On the other hand, investigations have also been carried out to improve the curability of compositions by

modifying the structure of reactive silyl group-containing organic polymers. For example, Patent Document 9 discloses a curable composition containing an organic polymer terminating in a reactive silyl group having three hydroxyl or hydrolyzable groups (such silyl group hereinafter referred to also as a "T terminal group"), for example a trialkoxysilyl group, and it is disclosed that such a T terminal group-containing organic polymer, when an organotin type catalyst is used as a silanol condensation catalyst, shows higher activity as compared with an organic polymer terminating in a reactive silyl group containing two hydroxyl or hydrolyzable groups (such silyl group hereinafter referred to also as a "D terminal group", for example a dialkoxysilyl group).

[0010] However, among the curable compositions comprising a T terminal group-containing organic polymer in combination with the above-mentioned non-organotin type silanol condensation catalysts, none has yet been found to have sufficient curing characteristics (surface curability, depth curability, adhesiveness, etc.) for practical use.

[0011] Thus, the characteristics of the curable compositions obtained are diverse depending on the combination of the reactive silyl group species used and the silanol condensation catalyst species used and, presumably, it is a very difficult task to develop curable compositions satisfying all of the requirements of the practical characteristics (adhesiveness, surface curability, depth curability and strength rise) using non-organotin type catalysts so far regarded as inferior in activity to organotin type catalysts; nevertheless, prompt development of such is awaited.

[0012] On the other hand, a plasticizer is sometimes added to curable compositions comprising the above-mentioned reactive silyl group-containing organic polymers for the purpose of reducing the viscosity of the compositions, improving the slump characteristic thereof and adjusting the mechanical characteristics, such as tensile strength and elongation, of cured products. Widely used as the plasticizer are phthalate ester type plasticizers such as di(2-ethylhexyl) phthalate because of their general-purpose properties.

[0013] However, in certain cases where the reactive silyl group-containing organic polymer, silanol condensation catalyst and phthalate ester type plasticizer are combined, the surface curability after storage may show decreases as compared with that before storage depending on the silanol condensation catalyst species used; thus, caution is needed.

[0014] Patent Document 10, Patent Document 6 and Patent Document 11 disclose, regarding curable compositions comprising an organotin type catalyst, a carboxylic acid tin salt and a carboxylic acid, respectively, as a silanol condensation catalyst, technologies of inhibiting the surface curability of the compositions from decreasing upon storage by using such a polyether type plasticizer as polypropylene glycol. However, as is evident from the examples given in Patent Document 11, the use of a polyether type plasticizer in the systems comprising a non-organotin type silanol condensation catalyst, such as a carboxylic acid tin salt or a carboxylic acid, indeed leads to improvements from the viewpoint of reduced surface curability after storage but tends to retard the curability before storage as compared with the use of a phthalate ester type plasticizer.

[0015] Any plasticizer has not yet been found out for obtaining curable compositions excellent in surface curability before and after storage by the combined use of a non-organotin type catalyst such as a carboxylic acid tin salt or a carboxylic acid, as mentioned above.

[0016] Further, it is known that, in cases where a carboxylic acid tin salt and a carboxylic acid are used in combination as a silanol condensation catalyst, the surface curability will not be reduced upon storage even when a phthalate ester type plasticizer is used, as disclosed in Patent Document 12.

[0017] Thus, the surface curability of the curable compositions obtained before and after storage are diverse depending on the plasticizer species used and the silanol condensation catalyst species used and, presumably, it is a technology very difficult to develop to secure both high surface curability and good storage stability (a characteristic of the curability showing no change even after storage) in systems in which a non-organotin type catalyst and a plasticizer are used in combination; nevertheless, prompt development of such technology is awaited, like in the case mentioned above.

[0018] On the other hand, in spite of the fact that it is known in the art that the combined use of an amine compound with the above-mentioned carboxylic acid metal salt or carboxylic acid can lead to improvements in curability, there are only a relatively small number of examples disclosing catalyst systems in which an amine compound alone is used. Patent Document 13 discloses a technology comprising using aryl group-substituted biguanide compounds, such as 1-(o-tolyl) biguanide, a conventionally known amine compound, as silanol condensation catalysts.

[0019] However, when the aryl group-substituted biguanide compounds or like guanidine compounds as disclosed in Patent Document 13 are used as silanol condensation catalysts for D terminal group-containing organic polymers, the resulting compositions are sometimes inferior in depth curability and strength rise, even if the compositions show good surface curability. When the addition level of the guanidine compound is increased so as to secure good surface curability, the resulting curable compositions are sometimes discolored.

[0020] Thus, among the curable composition systems in which a guanidine compound is used as a silanol condensation catalyst, any one that exhibits excellent curability and is little discolored has not yet been obtained; further, in the existing circumstances, the problem that the addition of a phthalate ester type plasticizer to such systems results in decreases in curability upon storage has not been solved as yet.

[0021] Patent Document 1: Japanese Kokai Publication S52-73998

[0022] Patent Document 2: Japanese Kokai Publication S63-6041

[0023] Patent Document 3: Japanese Kokai Publication H05-39428

[0024] Patent Document 4: Japanese Kokai Publication H09-12860

[0025] Patent Document 5: Japanese Kokai Publication 2000-313814

[0026] Patent Document 6: Japanese Kokai Publication 2000-345054

[0027] Patent Document 7: Japanese Kokai Publication 2003-206410

[0028] Patent Document 8: Japanese Kokai Publication H05-117519

[0029] Patent Document 9: WO98/47939

[0030] Patent Document 10: WO97/13820

[0031] Patent Document 11: WO05/97907

[0032] Patent Document 12: WO04/31299

[0033] Patent Document 13: Japanese Kokai Publication 2005-248175

SUMMARY OF THE INVENTION

[0034] It is an object of the invention to provide a curable composition which comprises a reactive silyl group-containing organic polymer and a guanidine compound as a non-organotin type catalyst, is less discolored, has excellent curing characteristics (adhesiveness, surface curability, depth curability, and strength rise) and can retain the curing characteristics even after storage.

[0035] The present inventors made intensive investigations to solve the problems mentioned above and, as a result, found it possible to obtain a curable composition which is less discolored, shows good adhesiveness, surface curability, depth curability and strength rise and can retain curability after storage in spite of its being a non-organotin type catalyst-containing composition when a specific reactive silyl group-containing organic polymer (A), a guanidine compound (B-1) as a silanol condensation catalyst and a plasticizer (C) are used and, at the same time, the addition level of the component (B-1) and the proportion of the phthalate ester type plasticizer in the component (C) are restricted. Based on such findings, the present invention has now been completed.

[0036] That is, the present invention relates to a curable composition which comprises:

(A) an organic polymer containing a silyl group capable of crosslinking under siloxane bond formation, the silyl group being a group represented by the general formula (1):



(wherein X represents a hydroxyl group or a hydrolyzable group and the three X groups may be mutually the same or different),

(B) a guanidine compound (B-1) as a silanol condensation catalyst, and

(C) a plasticizer,

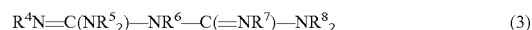
[0037] wherein the content of the component (B-1) is not lower than 0.1 part by weight but lower than 8 parts by weight per 100 parts by weight of the component (A), and a non-phthalate ester plasticizer accounts for 80 to 100% by weight of the (C) component plasticizer.

[0038] One preferred embodiment of the present invention relates to the above-mentioned curable composition, wherein the component (B-1) is a guanidine compound represented by the general formula (2):

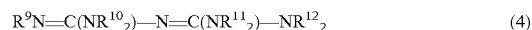


(wherein R^1 , the two R^2 's and the two R^3 's are independently an organic group or a hydrogen atom, provided that four or more of R^1 , the two R^2 's and the two R^3 's are independently an organic group other than an aryl group, or a hydrogen atom.

[0039] One further preferred embodiment of the present invention relates to the above-mentioned curable composition, wherein the component (B-1) represented by the general formula (2) is a biguanide compound represented by the general formula (3):



(wherein R^4 , the two R^5 's, R^6 , R^7 and the two R^8 's are independently an organic group or a hydrogen atom, and/or the general formula (4):



(wherein R^9 , the two R^{10} s, the two R^{11} s and the two R^{12} s are independently an organic group or a hydrogen atom).

[0040] One further preferred embodiment of the present invention relates to any of the above-mentioned curable compositions, wherein the component (B-1) is a guanidine compound having a melting point of not lower than 23° C.

[0041] One further preferred embodiment of the present invention relates to any of the above-mentioned curable compositions, wherein a main chain skeleton of the (A) component organic polymer contains at least one atom selected from among a hydrogen atom, a carbon atom, a nitrogen atom, an oxygen atom and a sulfur atom.

[0042] One further preferred embodiment of the present invention relates to any of the above-mentioned curable compositions, wherein the (A) component organic polymer comprises at least one species selected from the group consisting of polyoxyalkylene polymers, saturated hydrocarbon polymers and (meth)acrylate ester polymers.

[0043] One further preferred embodiment of the present invention relates to the above-mentioned curable composition, wherein the polyoxyalkylene polymer is a polyoxypropylene polymer.

[0044] One further preferred embodiment of the present invention relates to any of the above-mentioned curable compositions, wherein a main chain skeleton of the (A) component organic polymer contains a group represented by the general formula (5):



(wherein R^{13} is an organic group or a hydrogen atom).

[0045] One further preferred embodiment of the present invention relates to any of the above-mentioned curable compositions, which contains the (C) component plasticizer in an amount of 5 to 150 parts by weight per 100 parts by weight of the (A) component organic polymer.

[0046] One further preferred embodiment of the present invention relates to a one-pack curable composition which comprises any of the above-mentioned curable compositions.

[0047] Preferred as applications of the curable composition according to the present invention is a sealant or an adhesive which comprises any of the curable composition described above.

[0048] The present invention provides a curable composition which comprises a reactive silyl group-containing organic polymer and in which a guanidine compound is used as a non-organotin catalyst and the composition is less discolored and has good adhesiveness, surface curability, depth curability and strength rise, and can retain the curability even after storage.

DETAILED DESCRIPTION OF THE INVENTION

[0049] In the following, the present invention is described in detail.

[0050] The curable composition of the present invention satisfies the following characteristics.

[0051] The present invention includes a non-organotin type curable composition which comprises a specific reactive silyl group-containing organic polymer, a specific silanol condensation catalyst and a plasticizer.

[0052] The “non-organotin type curable composition”, so referred to herein, is a curable composition in which the addition level of an organotin compound is not higher than 50% by weight in the compound components each acting as a silanol condensation catalyst.

[0053] The “specific reactive silyl group-containing organic polymer” is an organic polymer (A) containing a terminal reactive silyl group with three hydroxyl groups or hydrolyzable groups bound to a silicon atom. Further, the “specific silanol condensation catalyst” is a guanidine compound (B-1).

[0054] Further, the composition contains the component (B-1) in an amount of not smaller than 0.1 part by weight but smaller than 8 parts by weight per 100 parts by weight of the component (A), and a non-phthalate ester type plasticizer accounts for 80 to 100% by weight of the plasticizer component (C).

[0055] The curable composition of the invention comprises, as an essential constituent (A), a reactive silyl group-containing organic polymer (hereinafter referred to also as “component (A)”, “reactive silyl group-containing organic polymer (A)” or “organic polymer (A)”).

[0056] The organic polymer (A) has, on an average, at least one reactive silyl group per molecule. The reactive silyl group, so referred to herein, is an organic group containing hydroxyl groups or hydrolyzable groups each bound to a silicon atom. The reactive silyl group-containing organic polymer (A) is crosslinked under siloxane bond formation as a result of a reaction promoted by a silanol condensation catalyst.

[0057] As the reactive silyl group, there may be mentioned groups represented by the general formula (1):



(wherein the three X groups are independently a hydroxyl group or a hydrolyzable group).

[0058] The organic polymer containing a terminal reactive silyl group with the three X groups (hydroxyl groups, hydrolyzable groups) bound to a silicon atom as represented by the general formula (1) is superior in curability to an organic polymer containing a terminal reactive silyl group represented by the general formula (6):



wherein the n R^{14} s are independently at least one selected from the group consisting of alkyl groups containing 1-20 carbon atoms, aryl groups containing 6-20 carbon atoms and aralkyl groups containing 7-20 carbon atoms; the (3-n) X groups are independently either a hydroxyl group or a hydrolyzable group; and n is the integer 1 or 2 and, therefore, even when the guanidine compound (B-1) is used as a silanol condensation catalyst in a smaller amount in the practice of the invention, good curability can be secured.

[0059] For securing the above effect, it is necessary in the practice of the invention that the organic polymer (A) have at least one reactive silyl group as defined by the general formula (1) per molecule on an average.

[0060] The curable composition of the present invention, which comprises a reactive silyl group-containing organic polymer (A) as the main component, is better in compatibility with the guanidine compound (B-1) used as the silanol condensation catalyst, as compared with a composition which comprises an inorganic polymer as the main component, for example polydimethylsiloxane, hence is preferred. Further, the curable composition comprising an organic polymer (A) is excellent in curability and the cured products obtained therefrom are characterized by excellent adhesiveness.

[0061] Further, for the same reasons, the organic polymer (A) preferably has a main chain skeleton containing at least

one atom selected from among a hydrogen atom, a carbon atom, a nitrogen atom, an oxygen atom and a sulfur atom.

[0062] The main chain skeleton of the organic polymer (A) is not particularly restricted but includes, polyoxyalkylene type polymers such as polyoxyethylene, polyoxypropylene, polyoxybutylene, polyoxytetramethylene, polyoxyethylene-polyoxypropylene copolymers and polyoxypropylene-polyoxybutylene copolymers; ethylene-propylene type copolymers, polyisobutylene, copolymers of isobutylene and isoprene or the like, polychloroprene, polyisoprene, copolymers of isoprene or butadiene and acrylonitrile and/or styrene or the like, polybutadiene and copolymers of isoprene or butadiene and acrylonitrile and styrene or the like, hydrocarbon type polymers such as hydrogenated polyolefin polymers derived from these polyolefin type polymers by hydrogenation; polyester type polymers obtained by condensation of a dibasic acid such as adipic acid and a glycol, or ring-opening polymerization of a lactone (s); (meth)acrylate ester polymers obtained by radical polymerization of such a compound as ethyl (meth)acrylate and butyl (meth)acrylate; vinyl polymers obtained by radical polymerization of such a compound as a (meth)acrylate ester compound, vinyl acetate, acrylonitrile and styrene; graft polymers obtained by polymerizing a vinyl compound in such polymers as mentioned above; polysulfide type polymers; polyamide type polymers such as polyamide 6 produced by ring-opening polymerization of ϵ -caprolactam, polyamide 6•6 produced by polycondensation of hexamethylenediamine and adipic acid, polyamide 6•10 produced by polycondensation of hexamethylenediamine and sebacic acid, polyamide 11 produced by polycondensation of ϵ -aminoundecanoic acid, polyamide 12 produced by ring-opening polymerization of ϵ -aminolauroctam, and copolymer polyamides composed of a plurality of the polyamides mentioned above; polycarbonate type polymers such as polycarbonates produced by polycondensation of bisphenol A and carbonyl chloride; diallyl phthalate type polymers; and like organic polymers.

[0063] Preferred among those mentioned above are organic polymers (A) having, as the main chain skeleton, saturated hydrocarbon type polymers such as polyisobutylene, hydrogenated polyisoprene and hydrogenated polybutadiene, polyoxyalkylene type polymers, (meth)acrylate ester polymers and polysiloxane type polymers, in view of their relatively low glass transition temperature and of good low-temperature resistance of cured products obtained therefrom.

[0064] The glass transition temperature of the reactive silyl group-containing organic polymer (A) is not particularly restricted but preferably is not higher than 20° C., more preferably not higher than 0° C., most preferably not higher than -20° C. When the glass transition temperature is higher than 20° C., the viscosity of the curable composition increases in the winter season or in cold districts, developing a tendency toward lowered workability and, further, the flexibility of cured products obtained decreases and the elongation thereof tends to decrease.

[0065] The glass transition temperature mentioned above can be determined by DSC measurement according to the method prescribed in JIS K 7121.

[0066] A curable composition comprising, as the main component, a saturated hydrocarbon type polymer and an organic polymer whose main chain skeleton is a polyoxyalkylene type polymer and a (meth)acrylate ester polymer is more

preferred since, when it is used as an adhesive or sealant, low-molecular-weight components scarcely migrate to (i.e. stain) adherends.

[0067] Further, an organic polymer whose main chain skeleton is a polyoxyalkylene type polymer and a (meth)acrylate ester polymer is particularly preferred since it is high in moisture permeability and, when used as a main component of a one-pack type adhesive or sealant, it is excellent in depth curability and gives cured products excellent in adhesiveness. Most preferred is an organic polymer whose main chain skeleton is a polyoxyalkylene type polymer.

[0068] The polyoxyalkylene type polymer to be used as the main chain skeleton of the organic polymer (A) is a polymer having a repeating unit represented by the general formula (7):



(R^{15} is a straight or branched alkylene group containing 1 to 14 carbon atoms).

[0069] The group R^{15} in the general formula (7) is not particularly restricted but may be any of the straight or branched alkylene groups containing 1 to 14 carbon atoms and, among those, straight or branched alkylene groups containing 2 to 4 carbon atoms are preferred.

[0070] The repeating unit defined by the general formula (7) is not particularly restricted but includes, for example, $-\text{CH}_2\text{O}-$, $-\text{CH}_2\text{CH}_2\text{O}-$, $-\text{CH}_2\text{CH}(\text{CH}_3)\text{O}-$, $-\text{CH}_2\text{CH}(\text{C}_2\text{H}_5)\text{O}-$, $-\text{CH}_2\text{C}(\text{CH}_3)_2\text{O}-$ and $-\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_2\text{O}-$.

[0071] The polyoxyalkylene type polymer may have one repeating unit species or a plurality of repeating unit species. In the case of use in the field of sealants and the like, in particular, an organic polymer (A) in which the main component of the main chain skeleton is a propylene oxide polymer is preferred since such polymer is noncrystalline and relatively low in viscosity.

[0072] A method of producing such a polyoxyalkylene type polymer is not particularly restricted but may be any of the methods known in the art. For example, mention may be made of the method using an alkali catalyst such as KOH, the method disclosed in Japanese Kokai Publication S61-215623 which uses, as a catalyst, a transition metal-porphyrin complex, such as a complex obtained by reacting an organoaluminum compound with porphyrin, the methods disclosed in Japanese Kokoku Publications S46-27250 and S59-15336 and U.S. Pat. Nos. 3,278,457, 3,278,458, 3,278,459, 3,427,256, 3,427,334 and 3,427,335, among others, which use, as a catalyst, a composite metal cyanide complex, the method disclosed in Japanese Kokai Publication H10-273512 which uses, as a catalyst, a polyphosphazene salt, and the method disclosed in Japanese Kokai Publication H11-060722 which uses, as a catalyst, a phosphazene compound.

[0073] The method of producing a reactive silyl group-containing polyoxyalkylene type polymer is not particularly restricted but may be any of the methods known in the art. For example, mention may be made of the methods disclosed in Japanese Kokoku Publications S45-36319 and S46-12154, Japanese Kokai Publications S50-156599, S54-6096, S55-13767, S55-13468 and S57-164123, Japanese Kokoku Publication H03-2450 and U.S. Pat. Nos. 3,632,557, 4,345,053, 4,366,307 and 4,960,844, among others, and the methods disclosed in Japanese Kokai Publications S61-197631, S61-215622, S61-215623, S61-218632, H03-72527, H03-47825 and H08-231707, among others, according to which poly-

mers high in molecular weight (number average molecular weight of 6,000 or higher) and narrow in molecular weight distribution (Mw/Mn of 1.6 or below) can be obtained.

[0074] In formulating the curable composition using the reactive silyl group-containing polyoxyalkylene type polymer mentioned above, the polymer may comprise a single species or a combination of a plurality of species thereof.

[0075] The saturated hydrocarbon type polymer to be used as the main chain skeleton of the organic polymer (A) is a polymer whose molecules are substantially free of any carbon-carbon unsaturated bond, except for an aromatic ring, and is excellent in heat resistance, weather resistance, durability and a moisture barrier property.

[0076] The saturated hydrocarbon type polymer is not particularly restricted but there may be mentioned (i) polymers derived from an olefin compound containing 2 to 6 carbon atoms, such as ethylene, propylene, 1-butene and isobutylene as the repeating unit species, (ii) polymers derived from a diene type compound, such as butadiene and isoprene as the repeating unit species, and (iii) polymers obtained by copolymerizing the above-mentioned diene type compound and the above-mentioned olefin type compound, followed by hydrogenation. Among these, isobutylene type polymers and hydrogenated polybutadiene type polymers are preferred in view of ease of functional-group introduction into an end thereof, ease of molecular weight control and adjustability of the number of terminal functional groups, among others; isobutylene type polymers are more preferred.

[0077] The isobutylene type polymer may be such one that all of the repeating units are derived from isobutylene or a copolymer with another compound. When the isobutylene type copolymer is used as the main chain skeleton, the polymer preferably has an isobutylene-derived repeating unit content, in each molecule, of not lower than 50% by weight, more preferably not lower than 80% by weight, particularly preferably 90 to 99% by weight, so that the cured products obtained may have excellent rubber characteristics.

[0078] A method of producing the saturated hydrocarbon type polymer is not particularly restricted but may be any of various conventional polymerization methods. Among them, the living polymerization method the development of which has been remarkable in recent years is preferred and, for example, the Inifer polymerization found by Kennedy et al. (J. P. Kennedy et al., J. Polymer Sci., Polymer Chem. Ed., 1997, 15, p. 2843) may be mentioned as a method of producing isobutylene-based polymers using the living polymerization method. This polymerization method enables introduction of various functional groups into molecular ends and the isobutylene type polymers obtained are known to have a molecular weight of about 500 to 100,000 with a molecular weight distribution of not broader than 1.5.

[0079] A method of producing the reactive silyl group-containing saturated hydrocarbon polymer is not particularly restricted but may be any of the methods known in the art, for example the methods disclosed in Japanese Kokoku Publications H04-69659 and H07-108928, Japanese Kokai Publications S63-254149, S64-22904 and H01-197509 and Japanese Patents Nos. 2539445 and 2873395 and Japanese Kokai Publication H07-53882.

[0080] In formulating the curable composition using the above-mentioned reactive silyl group-containing saturated hydrocarbon type polymer, the polymer may comprise a single species or a combination of a plurality of species thereof.

[0081] A (meth)acrylate ester polymer to be used as the main chain skeleton of the organic polymer (A) is a polymer in which the repeating unit is derived from a (meth)acrylate ester compound. The expression “(meth)acrylate ester” refers to an acrylate ester and/or a methacrylate ester and has the same meaning also in the description which follows.

[0082] The (meth)acrylate ester compound to be used as the repeating unit is not particularly restricted but includes such (meth)acrylate compounds as (meth)acrylic acid, methyl (meth)acrylate, ethyl (meth)acrylate, n-propyl (meth)acrylate, isopropyl (meth)acrylate, n-butyl (meth)acrylate, isobutyl (meth)acrylate, tert-butyl (meth)acrylate, n-pentyl (meth)acrylate, n-hexyl (meth)acrylate, cyclohexyl (meth)acrylate, n-heptyl (meth)acrylate, n-octyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, nonyl (meth)acrylate, decyl (meth)acrylate, dodecyl (meth)acrylate, phenyl (meth)acrylate, toluoyl (meth)acrylate, benzyl (meth)acrylate, 2-methoxyethyl (meth)acrylate, 3-methoxybutyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, stearyl (meth)acrylate, glycidyl (meth)acrylate, γ -(methacryloyloxypropyl)trimethoxysilane, γ -(methacryloyloxypropyl)dimethoxymethylsilane, (meth)acrylic acid-ethylene oxide adducts, trifluoromethylmethyl (meth)acrylate, 2-trifluoromethylethyl (meth)acrylate, 2-perfluoroethylethyl (meth)acrylate, 2-perfluoroethyl-2-perfluorobutylethyl (meth)acrylate, perfluoroethyl (meth)acrylate, trifluoromethyl (meth)acrylate, bis(trifluoromethylmethyl) (meth)acrylate, 2-trifluoromethyl-2-perfluoroethylethyl (meth)acrylate, 2-perfluorohexylethyl (meth)acrylate, 2-perfluorodecylethyl (meth)acrylate and 2-perfluorohexadecylethyl (meth)acrylate.

[0083] The (meth)acrylate ester polymer includes copolymers of a (meth)acrylate ester compound and a vinyl compound copolymerizable therewith. The vinyl compound is not particularly restricted but includes: styrene compounds such as styrene, vinyltoluene, α -methylstyrene, chlorostyrene, and styrenesulfonic acid and salts thereof; silyl group-containing vinyl compounds such as vinyltrimethoxysilane and vinyltriethoxysilane; maleic acid, maleic anhydride, and maleic acid monoalkyl esters and dialkyl esters; fumaric acid and fumaric acid monoalkyl esters and dialkyl esters; maleimide type compounds such as maleimide, methylmaleimide, ethylmaleimide, propylmaleimide, butylmaleimide, hexylmaleimide, octylmaleimide, dodecylmaleimide, stearylmaleimide, phenylmaleimide and cyclohexylmaleimide; nitrile group-containing vinyl compounds such as acrylonitrile and methacrylonitrile; amide group-containing vinyl compounds such as acrylamide and methacrylamide; vinyl esters such as vinyl acetate, vinyl propionate, vinyl pivalate, vinyl benzoate and vinyl cinnamate; alkenes such as ethylene and propylene; conjugated dienes such as butadiene and isoprene; vinyl chloride, vinylidene chloride, allyl chloride and allyl alcohol. It is also possible to use a plurality of these as copolymerization components.

[0084] Among the (meth)acrylate ester polymers obtained from the compounds mentioned above, those organic polymers which comprise, as the main chain skeleton, a copolymer of a styrene compound and a (meth)acrylate compound are preferred since they give cured products excellent in physical properties; those organic polymers which comprise, as the main chain skeleton, a copolymer of an acrylate ester compound and a methacrylate ester compound are more preferred, and those organic polymers which comprise, as the main chain skeleton, a polymer of an acrylate ester compound are particularly preferred.

[0085] For use in general architectural fields, the curable composition is required to be low in viscosity, while the cured products obtained therefrom are required to be low in modulus and high in elongation, weather resistance and thermal stability.

[0086] More preferred as ones meeting these requirements are organic polymers (A) whose main chain skeleton is derived from a butyl acrylate compound.

[0087] On the other hand, for use in automotive or like fields, the cured products obtained are required to be excellent in oil resistance.

[0088] More preferred as one giving cured products excellent in oil resistance is an organic polymer (A) whose main chain skeleton is a copolymer mainly derived from ethyl acrylate.

[0089] Curable compositions comprising the organic polymer (A) whose main chain skeleton is an ethyl acrylate-based copolymer tend to give cured products somewhat inferior in low-temperature characteristics (low-temperature resistance) in spite of their being excellent in oil resistance. For improving the low-temperature characteristics, replacement is made of a part of ethyl acrylate with butyl acrylate. Since, however, an increased proportion of butyl acrylate tends to impair the good oil resistance, the proportion thereof is preferably not higher than 40%, more preferably not higher than 30%, in cases of a field where oil resistance is required.

[0090] The use, as a comonomer component, of 2-methoxyethyl acrylate or 2-ethoxyethyl acrylate which has an oxygen atom introduced into the side chain alkyl group is also preferred for improving low-temperature characteristics and the like without causing decrease in oil resistance.

[0091] Since, however, the introduction of an alkoxy group having an ether bond in the side chain tends to render the cured products obtained inferior in thermal stability, the proportion thereof is preferably not higher than 40% in cases of use where thermal stability is required.

[0092] As mentioned above, it is possible to obtain an organic polymer (A) whose main chain skeleton is an ethyl acrylate-based copolymer and which is suited for various uses or can meet requirements by selecting the comonomer component species and varying the proportion thereof taking into consideration such physical properties as oil resistance, thermal stability and low temperature characteristics as required of the cured products obtained. For example, there may be mentioned, without any limitative meaning, copolymers of ethyl acrylate, butyl acrylate and 2-methoxyethyl acrylate copolymer (weight ratio: 40-50/20-30/30-20) as examples excellent in balance among such physical properties as oil resistance, thermal stability and low-temperature characteristics.

[0093] In the practice of the present invention, these preferred compounds may be copolymerized and, further, block-copolymerized with another compound and, on such occasion, the content of these preferred compounds is preferably not lower than 40% by weight.

[0094] A method of producing the (meth)acrylate ester polymer is not particularly restricted but may be any of the methods known in the art. Among them, the living radical polymerization method is preferably used in particular in view of the ease of high-rate introduction of a crosslinking functional group into a molecular chain end and the possibility of obtaining polymers narrow in molecular weight distribution and low in viscosity.

[0095] The polymers obtained by ordinary free radical polymerization using, for example, an azo compound or peroxide as a polymerization initiator tend to show an increased molecular weight distribution value generally not lower than 2 and an increased level of viscosity.

[0096] Among the methods of producing (meth)acrylate ester polymers using the above-mentioned "living radical polymerization method", the "atom transfer radical polymerization method" which uses an organic halide or sulfonyl halide compound as an initiator and a transition metal complex as a catalyst is preferred as the method of producing (meth)acrylate ester polymers containing a specific functional group since it has not only such characteristics of the "living radical polymerization" as the narrowness in molecular weight distribution and the capability to give polymers low in viscosity but also a high degree of freedom in selecting the initiator and catalyst and the capability to provide the polymers with a halogen or the like at ends thereof relatively advantageous to functional-group exchange reactions. As for the atom transfer radical polymerization method, there may be mentioned, for example, the method described in Matyjaszewski et al., *Journal of the American Chemical Society* (J. Am. Chem. Soc.), 1995, 117, p. 5614.

[0097] A method of producing the reactive silyl group-containing (meth)acrylate ester polymer is not particularly restricted but includes, for example, the free radical polymerization method using a chain transfer agent, as disclosed in Japanese Kokoku Publications H03-14068 and H04-55444 and Japanese Kokai Publication H06-211922, the atom transfer radical polymerization method disclosed in Japanese Kokai Publication H09-272714, and the like.

[0098] It is also possible to use a (meth)acrylate ester copolymer derived from a plurality of the (meth)acrylate ester compounds mentioned above as the main chain skeleton of the organic polymer (A).

[0099] As typical examples of the (meth)acrylate ester copolymer derived from a plurality of (meth)acrylate ester compounds, there may be mentioned copolymers whose main chain skeleton substantially comprises: a repeating unit having an alkyl group containing 1 to 8 carbon atoms as represented by the general formula (8):



(R^{16} is a hydrogen atom or a methyl group and R^{17} is an alkyl group containing 1 to 8 carbon atoms); and a repeating unit having an alkyl group containing 9 or more carbon atoms as represented by the general formula (9):



(R^{16} is as defined above referring to the general formula (8) and R^{18} is an alkyl group containing 9 or more carbon atoms).

[0100] The group R^{17} in the general formula (8) is not particularly restricted but may be any of the alkyl groups containing 1 to 8 carbon atoms, for example a methyl group, an ethyl group, a propyl group, an n-butyl group, a t-butyl group and a 2-ethylhexyl group; among these, alkyl groups containing 1 to 4 carbon atoms are preferred.

[0101] The group R^{17} contained in the copolymers is not always restricted to a single alkyl group species.

[0102] The group R^{18} in the general formula (9) is not particularly restricted but may be any of the alkyl groups containing 9 or more carbon atoms, for example a lauryl group, a dodecyl group, a cetyl group, a stearyl group and a behenyl group. Among these, alkyl groups containing 10 to

30 carbon atoms are preferred and long-chain alkyl groups containing 10 to 20 carbon atoms are more preferred.

[0103] The group R^{18} contained in the copolymers is not always restricted to a single alkyl group species.

[0104] The (meth)acrylate ester copolymer substantially comprises the repeating units defined by the general formula (8) and general formula (9). The term "substantially" as used herein means that the total content of the repeating units defined by the general formulas (8) and (9) in the copolymer is not lower than 50% by weight, and the total content of the repeating units defined by the general formulas (8) and (9) in the copolymer is preferably not lower than 70%.

[0105] The content ratio between the repeating units of general formulas (8) and (9) occurring in the copolymer as expressed in terms of the weight ratio (general formula (8): general formula (9)) is preferably 95:5 to 40:60, more preferably 90:10 to 60:40.

[0106] The (meth)acrylate ester copolymer comprises a copolymer of (meth)acrylate ester compounds used as the repeating units defined by the general formulas (8) and (9) and a vinyl compound copolymerizable therewith.

[0107] As the vinyl compound, there may be mentioned, for example, acrylic acids such as acrylic acid and methacrylic acid; amide group-containing compounds such as acrylamide, methacrylamide, N-methylolacrylamide and N-methylolmethacrylamide, epoxy group-containing compounds such as glycidyl acrylate and glycidyl methacrylate, amino group-containing compounds such as diethylaminoethyl acrylate, diethylaminoethyl methacrylate and aminoethyl vinyl ether; and, further, such compounds as acrylonitrile, styrene, α -methylstyrene, alkyl vinyl ethers, vinyl chloride, vinyl acetate, vinyl propionate and ethylene.

[0108] These reactive silyl group-containing organic polymers may be used singly or in combination of two or more species. More specifically, it is also possible to use an organic-polymer blend comprising two or more species selected from the group consisting of reactive silyl group-containing polyoxyalkylene type polymers, reactive silyl group-containing saturated hydrocarbon type polymers and reactive silyl group-containing (meth)acrylate ester polymers.

[0109] A method of producing the organic polymer blend comprising a reactive silyl group-containing polyoxyalkylene type polymer and a reactive silyl group-containing (meth)acryl ester polymer is not particularly restricted but there may be mentioned, for example, the methods disclosed in Japanese Kokai Publications S59-122541, S63-112642, H06-172631 and H11-116763, and the like.

[0110] The organic-polymer blend comprising a reactive silyl group-containing saturated hydrocarbon type polymer and a reactive silyl group-containing (meth)acrylate ester polymer is not particularly restricted but mention may be made of the polymers disclosed in Japanese Kokai Publications H01-168764 and 2000-186176, and the like.

[0111] Further, in addition to those mentioned above, the organic-polymer blends comprising a reactive silyl functional group-containing (meth)acrylate ester polymer can also be produced by a method comprising polymerizing a (meth)acrylate ester monomer in the presence of a reactive silyl group-containing polymer. This production method is not particularly restricted but there may be mentioned, for example, the methods disclosed in Japanese Kokai Publications S59-78223, S59-168014, S60-228516 and S60-228517.

[0112] In the main chain skeleton of the organic polymer (A), there may further be present, if necessary, another repeating unit containing, for example, a urethane bond, so long as the effects of the present invention are not significantly lessened thereby.

[0113] The urethane bond-containing repeating unit is not particularly restricted but there may be mentioned, for example, a repeating unit comprising a group formed by the reaction between an isocyanato group and an active hydrogen group (the group thus formed is hereinafter referred to also as an "amide segment").

[0114] The amide segment is an organic group represented by the general formula (5):



(R^{13} is a hydrogen atom or an organic group).

[0115] The amide segment is not particularly restricted but includes, for example, a urethane group formed by the reaction between an isocyanato group and a hydroxyl group; a urea group formed by the reaction between an isocyanato group and an amino group; and a thiourethane group formed by the reaction between an isocyanato group and a mercapto group.

[0116] Those organic groups formed by the reaction of an active hydrogen in the urethane group, the urea group and the thiourethane group with an isocyanato group also fall within the definition of "amide segment" as given herein.

[0117] A method of producing the reactive silyl group-containing organic polymer containing an amide segment in the main chain skeleton thereof is not particularly restricted but there may be mentioned, for example, the method comprising reacting an active hydrogen-terminated organic group-containing organic polymer with an excess of a polyisocyanate compound to give a polymer having an isocyanato group at a polyurethane type main chain end and, thereafter or simultaneously therewith, reacting all or part of the isocyanato groups in the polymer with a group W in a silicon compound represented by the general formula (10)



(R^{19} is a divalent organic group, more preferably a divalent hydrocarbon group containing 1 to 20 carbon atoms; the three X groups are independently a hydroxyl group or a hydrolyzable group; and W is a group containing at least one active hydrogen selected from the group consisting of a hydroxyl group, a carboxyl group, a mercapto group and an amino (primary or secondary) group), as disclosed in Japanese Kokoku Publication S46-12154 (U.S. Pat. No. 3,632,557), Japanese Kokai Publications S58-109529 (U.S. Pat. No. 4,374,237), S62-13430 (U.S. Pat. No. 4,645,816), H08-53528 (EP 0676403), and H10-204144 (EP 0831108), Japanese Kohyo Publication 2003-508561 (U.S. Pat. No. 6,197,912), Japanese Kokai Publications H06-211879 (U.S. Pat. No. 5,364,955), H10-53637 (U.S. Pat. No. 5,756,751), H11-100427, 2000-169544, 2000-169545 and 2002-212415, Japanese Patent 3,313,360, U.S. Pat. Nos. 4,067,844 and 3,711,445, Japanese Kokai Publication 2001-323040, and the like.

[0118] Mention may also be made of a method comprising reacting an active hydrogen-containing group occurring at an end of an organic polymer with the isocyanato group of a reactive silyl group-containing isocyanate compound represented by the general formula (11):



(R¹⁹ and X are as defined above referring to the general formula (10)), as disclosed in Japanese Kokai Publications H11-279249 (U.S. Pat. No. 5,990,257), 2000-119365 (U.S. Pat. No. 6,046,270), S58-29818 (U.S. Pat. No. 4,345,053), H03-47825 (U.S. Pat. No. 5,068,304), H11-60724, 2002-155145 and 2002-249538, WO 03/018658, WO 03/059981, and the like.

[0119] The active hydrogen-terminated group-containing organic polymer is not particularly restricted but includes, for example, hydroxyl group-terminated oxyalkylene polymers (polyether polyols), polyacrylic polyols, polyester polyols, hydroxyl group-terminated saturated hydrocarbon type polymers (polyolefin polyols), polythiol compounds and polyamine compounds.

[0120] Preferred among these are those organic polymers whose main chain skeleton comprises a polyether polyol, polyacrylic polyol and polyolefin polyol components, since they have a relatively low glass transition temperature and give cured products excellent in low-temperature resistance.

[0121] Those organic polymers comprising a polyether polyol component are low in viscosity, have good workability and give cured products showing good depth curability and adhesiveness, hence are particularly preferred. Curable compositions in which an organic polymer containing a polyacrylic polyol and saturated hydrocarbon type polymer component are more preferred since they give cured products having good weather resistance and thermal stability.

[0122] The polyether polyol preferably has, on an average, at least 0.7 terminal hydroxyl group per molecule.

[0123] The production method thereof is not particularly restricted but may be any of the methods known in the art, including, for example, a polymerization method using an alkali metal catalyst, and a polymerization method of an alkylene oxide using a polyhydroxy compound containing at least two hydroxyl groups per molecule as an initiator in the presence of a double metal cyanide complex or cesium.

[0124] Among the polymerization methods mentioned above, the polymerization method using a double metal cyanide complex is preferred since it gives polymers low in degree of unsaturation, narrow in molecular weight distribution (Mw/Mn) and low in viscosity, which give cured products excellent in acid resistance and weather resistance, among others.

[0125] The term "polyacrylic polyol" refers to a polyol whose skeleton is a (meth)acrylic acid alkyl ester (co)polymer and whose molecule contains a hydroxyl group.

[0126] As for the production method thereof, the living radical polymerization method is preferred and the atom transfer radical polymerization method is more preferred because of capability of their giving polymers narrow in molecular weight distribution and possibly low in viscosity. Also preferred is the polymerization method involving the so-called SGO process in which an acrylic acid alkyl ester type compound is continuously bulk-polymerized under high-temperature and high-pressure conditions, as disclosed in Japanese Kokai Publication 2001-207157. As such a polyacrylic polyol, there may be mentioned ARUFON UH-2000 (product of Toagosei Co., Ltd.), and the like.

[0127] The polyisocyanate compound is not particularly restricted but includes, for example, an aromatic type polyisocyanate such as toluene (tolylene) diisocyanate, diphenylmethane diisocyanate and xylylene diisocyanate; and an aliphatic type polyisocyanate such as isophorone diisocyanate and hexamethylene diisocyanate.

[0128] The silicon compound defined by the general formula (10) is not particularly restricted but there may be mentioned, for example, amino group-containing silane compounds such as γ -aminopropyltrimethoxysilane, N-(β -aminoethyl)- γ -aminopropyltrimethoxysilane, γ -(N-phenyl)aminopropyltrimethoxysilane, N-ethylaminoisobutyltrimethoxysilane, N-cyclohexylaminomethyltriethoxysilane, N-cyclohexylaminomethyl-diethoxymethylsilane and N-phenylaminomethyltrimethoxysilane; hydroxyl group-containing silane compounds such as γ -hydroxypropyltrimethoxysilane; and mercapto group-containing silane compounds such as γ -mercaptopropyltrimethoxysilane.

[0129] As the silicon compound represented by the general formula (10), there may further be mentioned Michael addition products derived from various α,β -unsaturated carbonyl compounds and a primary amino group-containing silane compound or Michael addition products derived from various (meth) acryloyl group-containing silane compounds and a primary amino group-containing compound, as disclosed in Japanese Kokai Publications H06-211879 (U.S. Pat. No. 5,364,955), H10-53637 (U.S. Pat. No. 5,756,751), H10-204144 (EP 0831108) 2000-169544 and 2000-169545.

[0130] The reactive silyl group-containing isocyanate compound defined by the general formula (11) is not particularly restricted but includes, for example, γ -trimethoxysilylpropyl isocyanate, γ -triethoxysilylpropyl isocyanate, γ -methyldimethoxysilylpropyl isocyanate, γ -methyldiethoxysilylpropyl isocyanate, trimethoxysilylmethyl isocyanate, triethoxymethylsilylmethyl isocyanate, dimethoxymethylsilylmethyl isocyanate and diethoxymethylsilylmethyl isocyanate.

[0131] As the reactive silyl group-containing isocyanate compound defined by the general formula (11), there may further be mentioned the reaction products derived from a silicon compound of the general formula (10) and an excess of a polyisocyanate compound, as disclosed in Japanese Kokai Publication 2000-119365 (U.S. Pat. No. 6,046,270).

[0132] When the amide segment content is high in the main chain skeleton of the organic polymer serving as the (A) component in the practice of the present invention, the organic polymer shows a high viscosity and sometimes gives a composition poor in workability. Conversely, the amide segment in the main chain skeleton of the (A) component tends to improve the curability of the composition according to the present invention.

[0133] The hydrolyzable group represented by X in the general formula (1) is not particularly restricted but includes those hydrolyzable groups which are known in the art, for example, a hydrogen atom, halogen atoms, and an alkoxy group, an acyloxy group, a ketoxymate group, an amino group, an amide group, an acid amide group, an aminoxy group, a mercapto group and an alkenyloxy group. Among these, a hydrogen atom, an alkoxy group, an acyloxy group, a ketoxymate group, an amino group, an amide group, an aminoxy group, a mercapto group and an alkenyloxy group are preferred, and an alkoxy group is more preferred from the viewpoints of mild hydrolyzability and easy handleability.

[0134] The reactive silyl group defined by the general formula (1) is not particularly restricted but includes, for example, a trimethoxysilyl group, a triethoxysilyl group and a triisopropoxysilyl group. Among these, a trimethoxysilyl

group and triethoxysilyl group are preferred since it has high activity and affords good curability, and a trimethoxysilyl group is more preferred.

[0135] Further, a triethoxysilyl group is particularly preferred since the alcohol formed upon hydrolysis reaction of the reactive silyl group is highly safe ethanol.

[0136] A method of introducing the reactive silyl group is not particularly restricted but includes such methods known in the art as the methods (a) to (c) shown below.

[0137] (a) A method comprising: reacting a polymer containing such a functional group as a hydroxyl group in the molecule with an organic compound containing an active group reactive with this functional group as well as an unsaturated group to give an unsaturated group-containing polymer; or copolymerizing a polymer containing such a functional group as a hydroxyl group in the molecule with an unsaturated group-containing epoxy compound to give an unsaturated group-containing polymer, and then reacting the reaction product obtained with a reactive silyl group-containing hydrosilane for hydrosilylation.

[0138] (b) A method comprising reacting the unsaturated group-containing organic polymer obtained in the same manner as described above in (a) with a compound containing a mercapto group and a reactive silyl group.

[0139] (c) A method comprising reacting an organic polymer containing such a functional group as a hydroxyl group, an epoxy group or an isocyanato group in the molecule with a compound containing a functional group reactive with this function group and a reactive silyl group.

[0140] Among these methods, the method (a) or the method (c) in such a mode that a hydroxyl group-terminated polymer is reacted with a compound containing an isocyanato group and reactive silyl group is preferred in view of the fact that a high conversion rate can be attained in a relatively short period of time.

[0141] The method (a) is more preferred since curable compositions based on the reactive silyl group-containing organic polymer obtained by the method (a) tends to be lower in viscosity than curable compositions based on the organic polymer obtained by the method (c) and, as a result, curable compositions having good workability can be obtained and, further, the organic polymer obtained by the method (b) has a stronger mercaptosilane-due odor as compared with the organic polymer obtained by the method (a).

[0142] The hydrosilane compound to be used in carrying out the method (a) is not particularly restricted but includes, for example, halogenated hydrosilanes such as trichlorosilane; alkoxy silanes such as trimethoxysilane, triethoxysilane, and 1-[2-(trimethoxysilyl)ethyl]-1,1,3,3-tetramethyldisiloxane.

[0143] Among these, alkoxyhydrosilanes are preferred because of the mild hydrolyzability and easy handleability of curable compositions based on the organic polymer (A) obtained and, among the alkoxyhydrosilanes, trimethoxysilane is preferred since curable compositions based on the organic polymer (A) obtained are superior in curability and restorability.

[0144] The synthetic method (b) is not particularly restricted but may be, for example, the method of introducing a mercapto group- and reactive silyl group-containing compound into an unsaturated-bond site in the organic polymer by a radical addition reaction in the presence of a radical initiator and/or a radical generation source. The mercapto group- and reactive silyl group-containing compound is not particularly

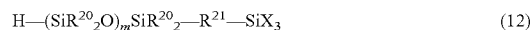
restricted but includes, for example, γ -mercaptopropyltrimethoxysilane, γ -mercaptopropyltriethoxysilane, mercaptomethyl trimethoxysilane and mercaptomethyltriethoxysilane.

[0145] The method of reacting a hydroxyl group-terminated polymer with an isocyanato group- and reactive silyl group-containing compound according to the synthetic method (c) is not particularly restricted but may be, for example, a method disclosed in Japanese Kokai Publication H03-47825. The isocyanato group- and reactive silyl group-containing compound is not particularly restricted but includes, for example, γ -isocyanatopropyltrimethoxysilane, γ -isocyanatopropyltriethoxysilane, isocyanatomethyltrimethoxysilane and isocyanatomethyltriethoxysilane.

[0146] In the case of silane compounds containing a silicon atom with three hydrolyzable groups bound thereto, for example trimethoxysilane, the disproportionation reaction may proceed rapidly in certain cases. The progress of the disproportionation reaction may sometimes result in the formation of such an unstable compound as dimethoxysilane, rendering the handling difficult.

[0147] In the case of γ -mercaptopropyltrimethoxysilane and γ -isocyanatopropyltrimethoxysilane, however, such disproportionation reaction will not proceed. Therefore, in the case of using, as the silyl group, a group containing a silicon atom with three hydrolyzable groups bound thereto, for example a trimethoxysilyl group, in the practice of the invention, the synthetic method (b) or (c) is preferably employed.

[0148] On the other hand, in the case of silane compounds represented by the general formula (12):



(wherein the three X groups are independently a hydroxyl group or a hydrolyzable group; the $(2m+2)$ R^{20} 's are independently a hydrocarbon group, preferably, from the availability and cost viewpoint, a hydrocarbon group containing 1 to 20 carbon atoms, more preferably a hydrocarbon group containing 1 to 8 carbon atoms, particularly preferably a hydrocarbon group containing 1 to 4 carbon atoms; R^{21} is a divalent organic group, preferably from the availability and cost viewpoint, a divalent hydrocarbon group containing 1 to 12 carbon atoms, more preferably a divalent hydrocarbon group containing 2 to 8 carbon atoms, particularly preferably a divalent hydrocarbon group containing 2 carbon atoms; and m is an integer from 0 to 19, preferably, from the availability and cost viewpoint, 1), the disproportionation reaction will not proceed.

[0149] Therefore, for introducing a group containing a silicon atom with three hydrolyzable groups bound thereto by the synthetic method (a), a silane compound represented by the general formula (12) is preferably used.

[0150] As the silane compound represented by the general formula (12), there may be mentioned 1-[2-(trimethoxysilyl)ethyl]-1,1,3,3-tetramethyldisiloxane, 1-[2-(trimethoxysilyl)propyl]-1,1,3,3-tetramethyldisiloxane and 1-[2-(trimethoxysilyl)hexyl]-1,1,3,3-tetramethyldisiloxane, among others.

[0151] The reactive silyl group-containing organic polymer (A) to be used may have either a straight chain structure or a branched chain structure in the molecule thereof, and the number average molecular weight thereof, as expressed in terms of the value on a polystyrene equivalent basis as derived from the value measured by GPC, is preferably 500 to 100,000, more preferably 1,000 to 50,000, particularly preferably 3,000 to 30,000. When the number average molecular weight

is lower than 500, the cured products obtained tend to be inferior in elongation characteristics and, when it is in excess of 100,000, the resulting curable composition becomes high in viscosity and tends to be inferior in workability.

[0152] The number of reactive silyl groups contained in each molecule of the organic polymer (A) is preferably not smaller than 1 on an average; it is preferably 1.1 to 5. When the number of reactive silyl groups contained in each molecule is smaller than 1 on an average, the curable composition tends to be inferior in curability and the cured products obtained show a tendency toward failure to exhibit a good rubber elastic behavior.

[0153] The reactive silyl group may occur at a main chain end or at a side chain end, or at both. In particular, when the reactive silyl group occurs only at a main chain end, the effective network size in the organic polymer component contained in the cured products obtained becomes increased, so that it becomes easy to obtain rubber-like cured products showing high strength, high elongation and low elastic modulus.

[0154] The curable composition according to the present invention comprises, as an essential component, a guanidine compound (B-1) as a silanol condensation catalyst (component (B)).

[0155] By using a guanidine compound (B-1) as a silanol condensation catalyst, in spite of its being a non-organotin catalyst, it becomes possible for the curable composition according to the present invention to show practical curability and for the cured products obtained to be little discolored and to show good adhesiveness against various adherends by adjusting the addition level.

[0156] The guanidine compound (B-1) is not particularly restricted but may be any of the guanidine compounds known in the art. Among them, compounds represented by the general formula (2) are preferred since they are high in activity and good in curability.



(wherein R^1 , the two R^2 's and the two R^3 's are independently an organic group or a hydrogen atom. Any four or more of R^1 , the two R^2 's and the two R^3 's may be an organic group other than an aryl group or a hydrogen atom.)

[0157] Preferred as R^1 in the general formula (2) is a hydrogen atom or a hydrocarbon group since, in such a case, the amidine compound is readily available and can provide the organic polymer (A) with good curability; more preferred is a hydrocarbon group in which the carbon atom at position 1 is saturated.

[0158] When R^1 is an organic group or a hydrocarbon group, the number of carbon atoms therein is preferably 1 to 20, more preferably 1 to 10, since, in such a case, the guanidine compound is readily available.

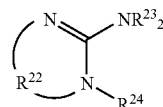
[0159] Each of the two R^2 's and the two R^3 's is preferably a hydrogen atom or a hydrocarbon group containing 1 to 20 carbon atoms, more preferably a hydrogen atom or a hydrocarbon group containing 1 to 10 carbon atoms, since, in such a case, the amidine compound is readily available and can provide the organic polymer (A) with good curability.

[0160] Further, since the cured products obtained show excellent adhesiveness, it is preferred that at least any one of R^1 , the two R^2 's and the two R^3 's be an aryl group.

[0161] However, the curability of the curable composition tends to decrease with the increase in the number of aryl groups substituted for the guanidine groups and, therefore, it

is preferred that at least any four of R^1 , the two R^2 's and the two R^3 's be either an organic group other than an aryl group or a hydrogen atom.

[0162] In view of their ability to provide the organic polymer (A) with excellent curability, those guanidine compounds represented by the general formula (2) are preferred to be guanidine compounds in which any two or more of R^1 , the two R^2 's and the two R^3 's are bound together to form a ring structure, and among these, those cyclic guanidine compounds represented by the general formula (13) are more preferred.



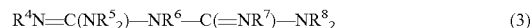
[Chem. 1]

[0163] (R^{22} is a divalent organic group, the two R^{23} 's and R^{24} are independently an organic group or a hydrogen atom. R^{23} and R^{24} may be bound together to form a ring structure.)

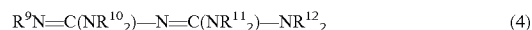
[0164] From the viewpoints of ready availability and ability to provide the organic polymer (A) with excellent curability, R^{22} in the general formula (13) is preferably a divalent hydrocarbon group containing 1 to 10 carbon atoms, more preferably a divalent hydrocarbon group containing 1 to 10 carbon atoms in which the carbon atom at position 1 is saturated, and among these, a divalent hydrocarbon group containing 1 to 5 carbon atoms is still more preferred, and a divalent hydrocarbon group containing 2 or 3 carbon atoms is particularly preferred.

[0165] From the viewpoints of ready availability and ability to provide the organic polymer (A) with excellent curability, the two R^{23} 's and R^{24} in the general formula (13) are preferably a hydrogen atom or a hydrocarbon group containing 1 to 20 carbon atoms, more preferably a hydrogen atom or a hydrocarbon group containing 1 to 10 carbon atoms. Further, it is preferred that any two of the two R^{23} 's and R^{24} be bound together to form a ring structure.

[0166] In cases where the cured products obtained are used in those fields of application in which they are required to show excellent adhesiveness in particular, compounds represented by the general formula (3) and/or general formula (4) are preferred as the guanidine compound represented by the general formula (2).



(R^4 , the two R^5 's, R^6 , R^7 and the two R^8 's are independently an organic group or a hydrogen atom.)



(R^9 , the two R^{10} 's, the two R^{11} 's and the two R^{12} 's are independently an organic group or a hydrogen atom.)

[0167] Those guanidine compounds of the general formula (2) in which either one of $-NR^2_2$ and $-NR^3_2$ is $-NR-C(=NR)-NR_2$, $-N=C(NR_2)-NR_2$ or a like type organic group, as shown in the general formula (3) or (4), are called biguanide compounds.

[0168] R^4 , the two R^5 's, R^6 , R^7 and the two R^8 's each in the general formula (3) is preferably a hydrogen atom or a hydrocarbon group containing 1 to 20 carbon atoms, more preferably a hydrogen atom or a hydrocarbon group containing 1 to 10 carbon atoms, since the corresponding compounds are

readily available and provide the organic polymer (A) with excellent curability and the cured products obtained show excellent adhesiveness.

[0169] It is preferred that at least any one of R⁴, the two R⁵s, R⁶, R⁷ and the two R⁸s be an aryl group, since, then, the cured products obtained show excellent adhesiveness and can maintain good physical characteristics over a long period of time, without experiencing such a trouble as bleeding out from the surface.

[0170] Referring to the general formula (4), R⁹, the two R¹⁰s, the two R¹¹s and the two R¹²s each is preferably a hydrogen atom or a hydrocarbon group containing 1 to 20 carbon atoms, more preferably a hydrogen atom or a hydrocarbon group containing 1 to 10 carbon atoms, since the corresponding compounds provide the organic polymer (A) with good curability and the cured products obtained show excellent adhesiveness.

[0171] It is preferred that at least any one of R⁹, the two R¹⁰s, the two R¹¹s and the two R¹²s be an aryl group, since the cured products obtained show excellent adhesiveness and can maintain good physical characteristics over a long period of time, without experiencing such a trouble as bleeding out from the surface.

[0172] The guanidine compound (B-1) preferably has a melting point of not lower than 23° C., more preferably not lower than 50° C., still more preferably not lower than 80° C., particularly preferably not lower than 120° C. When the melting point is lower than 23° C., a guanidine compound (B-1)-derived liquid tends to bleed out, namely flow out onto the surface of the cured product, causing a problem of soiling one's hand upon touching of the hand with the cured product surface.

[0173] The number of carbon atoms contained in the guanidine compound (B-1) represented by the general formula (2) is preferably not smaller than 2, more preferably not smaller than 6, particularly preferably not smaller than 7.

[0174] When the number of carbon atoms is smaller than 2 (namely when the molecular weight is low), the volatility of the compound becomes increased, causing a tendency toward pollution of the work environment. It is not necessary to particularly specify the upper limit to the number of carbon atoms contained in the guanidine compound (B-1); it is generally preferred, however, that the number be not larger than 10,000. For the same reasons as mentioned above, the guanidine compound (B-1) preferably has a molecular weight of not lower than 60, more preferably not lower than 120, particularly preferably not lower than 130. It is not necessary to particularly specify the upper limit to the molecular weight; it is generally preferred, however, that the molecular weight be not higher than 100,000.

[0175] The guanidine compound (B-1) (inclusive of the biguanide compound) is not particularly restricted but includes: guanidine compounds such as guanidine, 1,1,2-trimethylguanidine, 1,2,3-trimethylguanidine, 1,1,3,3-tetramethylguanidine, 1,1,2,2,3-pentamethylguanidine, 2-ethyl-1,1,3,3-tetramethylguanidine, 1-benzylguanidine, 1,3-dibenzylguanidine, 1-benzyl-2,3-dimethylguanidine, 1-phenylguanidine, 1-(o-tolyl)guanidine, N-(2-imidazolin-2-yl)-1-naphthalenamine, 2-phenyl-1,3-dicyclohexylguanidine, 1-benzylaminoguanidine, 1-(benzyloxy)guanidine, 1,1'-[4-(dodecyloxy)-m-phenylene]bisguanidine, guanylthiourea, dicyandiamide, 2-[(5,6,7,8-tetrahydronaphthalen-1-yl)amino]-2-imidazoline, 1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-n-

propyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-isopropyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-n-butyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-n-cyclohexyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-phenyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene and 2,3,5,6-tetrahydro-3-phenyl-1H-imidazo[1,2-a]imidazole; and biguanide compounds such as biguanide, 1-methylbiguanide, 1-n-butylbiguanide, 1-(2-ethylhexyl)biguanide, 1-n-octadecylbiguanide, 1,1-dimethylbiguanide, 1,1-diethylbiguanide, 1-cyclohexylbiguanide, 1-allylbiguanide, 1-phenylbiguanide, 1-(o-tolyl)biguanide (OTBG), 1-(2-chlorophenyl)biguanide, 1-benzylbiguanide, 1-(2-phenylethyl)biguanide, 3-(2-phenylethyl)biguanide, N,N-diamidinoaniline, 1,5-ethylenebiguanide, 1-morpholinobiguanide, 3-morphorinobiguanide, 1-(4-chlorobenzyloxy)biguanide, 1-n-butyl-N2-ethylbiguanide, 1,1'-ethylenebisbiguanide, 1-[3-(diethylamino)propyl]biguanide, 1-[3-(dibutylamino)propyl]biguanide, N,N"-dihexyl-3,12-diimino-2,4,11,13-tetraazatetradecanedia mine, 1-(morpholinosulfonyl)benzylbiguanide, 1-(hydroxymethyl)biguanide, 1-(2-hydroxyethyl)biguanide, 1,2-diisopropyl-3-[bis(dimethylamino)methylene]guanidine and 5-[3-(2,4,5-trichlorophenoxy)propoxy]-1-isopropylbiguanide.

[0176] Either a single species among these guanidine compounds may be incorporated in the curable composition or a combination of a plurality thereof may be incorporated in the curable composition.

[0177] Among the guanidine compounds mentioned above, biguanide compounds are preferred since the curable compositions obtained show good adhesiveness. More specifically, biguanide, 1-n-butylbiguanide, 1,1-dimethylbiguanide, 1-phenylbiguanide and OTBG are preferred, and OTBG is more preferred.

[0178] From the viewpoint that bleeding out from the cured products obtained can be inhibited, such guanidine compounds having a melting point of not lower than 23° C. as 1,5,7-triazabicyclo[4.4.0]dec-5-ene, 1-phenylguanidine, 1-n-butylbiguanide, 1,1-dimethylbiguanide, 1-phenylbiguanide and OTBG are preferred, and 1-phenylguanidine and OTBG are more preferred.

[0179] From the viewpoint of excellent curability of the curable composition, such cyclic guanidine compounds as 1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, 7-n-propyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene, and 7-n-cyclohexyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene are preferred, and 1,5,7-triazabicyclo[4.4.0]dec-5-ene and 7-methyl-1,5,7-triazabicyclo[4.4.0]dec-5-ene are more preferred.

[0180] The addition level of the guanidine compound (B-1) is essentially not less than 0.1 part by weight and below 0.8 parts by weight, more preferably not less than 0.5 part by weight and below 5 parts by weight, particularly preferably not less than 1 part by weight and below 3.5 parts by weight, per 100 parts by weight of the (A) component organic polymer.

[0181] When the addition level of the guanidine compound (B-1) is below 0.1 part by weight, any practical rate of curing in the curable composition may not be obtained in some instances and, further, sometimes, it becomes difficult for the curing reaction to proceed to a sufficient extent. On the other hand, when the addition level of the guanidine compound (B-1) is in excess of 8 parts by weight, the curable composition tends to be colored.

[0182] While the curable composition of the present invention uses a guanidine compound (B-1) as a silanol condensa-

tion catalyst, another silanol condensation catalyst may be used, if necessary, in combination with the amidine compound so long as the effects of the present invention will not be reduced.

[0183] The silanol condensation catalyst other than the guanidine compound is not particularly restricted but includes, for example, carboxylic acid metal salts such as tin carboxylates, lead carboxylates, bismuth carboxylates, potassium carboxylates, calcium carboxylates, barium carboxylates, titanium carboxylates, zirconium carboxylates, hafnium carboxylates, vanadium carboxylates, manganese carboxylates, iron carboxylates, cobalt carboxylates, nickel carboxylates and cerium carboxylates; titanium compounds such as tetrabutyl titanate, tetrapropyl titanate, titanium tetrakis(acetylacetonate), bis(acetylacetonato)diisopropoxytitanium and diisopropoxytitanium bis(ethyl acetoacetate); organotin compounds such as dibutyltin dilaurate, dibutyltin maleate, dibutyltin phthalate, dibutyltin dioctanoate, dibutyltin bis(2-ethylhexanoate), dibutyltin bis(methyl maleate), dibutyltin bis(ethyl maleate), dibutyltin bis(butyl maleate), dibutyltin bis(octyl maleate), dibutyltin bis(tridecyl maleate), dibutyltin bis(benzyl maleate), dibutyltin diacetate, dioctyltin bis(ethyl maleate), dioctyltin bis(octyl maleate), dibutyltin dimethoxide, dibutyltin bis(nonylphenoxide), dibutenyltin oxide, dibutyltin oxide, dibutyltin bis(acetylacetonate), dibutyltin bis(ethyl acetoacetate), reaction products of dibutyltin oxide-silicate compound and reaction products of dibutyltin oxide-phthalic acid ester; aluminum compounds such as aluminum tris(acetylacetonate), aluminum tris(ethyl acetoacetate) and diisopropoxyaluminum ethyl acetoacetate; zirconium compounds such as zirconium tetrakis(acetylacetonate); various metal alkoxides such as tetrabutoxyhafnium; organic acid phosphoric acid esters; organic sulfonic acids such as trifluoromethanesulfonic acid and dodecylbenzenesulfonic acid; inorganic acids such as hydrochloric acid, phosphoric acid and boronic acid; and so forth.

[0184] The use of such a silanol condensation catalyst other than a guanidine compound in combination with the guanidine compound is expected to enhance the catalytic activity and thus improve the depth curability and thin-layer curability of the curable composition and the adhesiveness and other properties of the cured products obtained. Among those enumerated above, titanium compounds, aluminum compounds and organic sulfonic acids, among others, are preferred since the surface curability of the organic polymer (A) is more enhanced by the use thereof; diisopropoxytitanium bis(ethyl acetoacetate), diisopropoxyaluminum ethyl acetoacetate and dodecylbenzenesulfonic acid are more preferred.

[0185] The combined use of titanium compounds is also preferred since the use gives curable compositions with increased strength and elongation; among them, diisopropoxytitanium bis(ethyl acetoacetate) is more preferred. The combined use of sulfonic acids is preferred since the solubility of the guanidine compound (B-1) into the curable composition is increased thereby; among them, dodecylbenzenesulfonic acid is more preferred in view of its ready availability.

[0186] Since, however, when an organotin compound is used in combination, the toxicity of the curable composition tends to increase with the increase in organotin addition level, the addition level of the organotin compound is preferably as low as possible and, more specifically, it is preferably not higher than 1 part by weight, more preferably not higher than 0.5 part by weight, particularly preferably not higher than

0.05 part by weight, per 100 parts by weight of the organic polymer (A); substantial absence thereof is most preferred.

[0187] The organotin compound addition level in the "non-organotin type curable composition" so referred to herein is such that the organotin compound amounts to not more than 50% by weight, preferably not more than 30% by weight, more preferably not more than 10% by weight, particularly preferably not more than 1% by weight, of the compound components acting as silanol condensation catalysts; substantial absence thereof is most preferred. The curable composition of the present invention is preferably a non-organotin type curable composition and, from the viewpoints of toxicity and environmental stress, it is more preferably a tin-free curable composition containing substantially none of such tin compounds as organotin type compounds and tin carboxylates, still more preferably an organotin-free and carboxylic acid metal salt-free curable composition containing substantially none of organotin compounds and various carboxylic acid metal salts, particularly preferably a metal catalyst-free curable composition containing substantially none of the above-mentioned metal element-containing curing catalysts such as carboxylic acid metal salts, titanium compounds, organotin compounds, organoaluminum compounds and zirconium compounds.

[0188] In cases where a metal compound other than an organotin is used in combination, the addition level thereof more specifically is preferably not higher than 5 parts by weight, more preferably not higher than 2 parts by weight, per 100 parts by weight of the organic polymer (A), and substantial absence thereof is most preferred. Further, carboxylic acids or phenols may be added as a promoter, if necessary, to the curable composition according to the invention so long as the effects of the present invention will not be reduced.

[0189] The carboxylic acid used as a promoter is not particularly restricted but includes straight-chain saturated fatty acids such as acetic acid, propionic acid, butyric acid, valeric acid, caproic acid, enanthic acid, caprylic acid, 2-ethylhexanoic acid, pelargonic acid, capric acid, undecanoic acid, lauric acid, tridecyl acid, myristic acid, pentadecyl acid, palmitic acid, heptadecyl acid, stearic acid, nonadecanoic acid, arachic acid, behenic acid, lignoceric acid, cerotic acid, montanic acid, melissic acid and lacceric acid; monoenoic unsaturated fatty acids such as undecylenic acid, linderic acid, tsuzuic acid, physeteric acid, myristoleic acid, 2-hexadecenoic acid, 6-hexadecenoic acid, 7-hexadecenoic acid, palmitoleic acid, petroselinic acid, oleic acid, elaidic acid, asclepic acid, vaccenic acid, gadoleic acid, gondoic acid, cetoleic acid, erucic acid, brassidic acid, selacholeic acid, ximenic acid, lumequeic acid, acrylic acid, methacrylic acid, angelic acid, crotonic acid, isocrotonic acid and 10-undecenoic acid; polyenoic unsaturated fatty acids such as linoleic acid, linolenic acid, 10,12-octadecadienoic acid, hiragonic acid, α -eleostearic acid, β -eleostearic acid, punicic acid, linolenic acid, 8,11,14-eicosatrienoic acid, 7,10,13-docosatrienoic acid, 4,8,11,14-hexadecatetraenoic acid, moroctic acid, stearidonic acid, arachidonic acid, 8,12,16,19-docosatetraenoic acid, 4,8,12,15,18-eicosapentaenoic acid, clupanodonic acid, nisinic acid and docosahexaenoic acid; branched fatty acids such as 1-methylbutyric acid, isobutyric acid, 2-ethylbutyric acid, isovaleric acid, tuberculostearic acid, pivalic acid, 2,2-dimethylbutyric acid, 2-ethyl-2-methylbutyric acid, 2,2-diethylbutyric acid, 2,2-dimethylvaleric acid, 2-ethyl-2-methylvaleric acid, 2,2-diethylvaleric acid, 2,2-dimethylhexanoic acid, 2,2-diethylhexanoic acid, 2,2-

dimethyloctanoic acid, 2-ethyl-2,5-dimethylhexanoic acid, neodecanoic acid and versatic acid; triple bond-containing fatty acids such as propiolic acid, tariric acid, stearolic acid, crepenynic acid, xymenynic acid and 7-hexadecynoic acid; alicyclic carboxylic acids such as naphthenic acid, malvalic acid, sterculic acid, hydnocarpic acid, chaulmoogric acid, gorlic acid, 1-methylcyclopentanecarboxylic acid, 1-methylcyclohexanecarboxylic acid, 2-methylbicyclo[2.2.1]-5-heptene-2-carboxylic acid, 1-adamantanecarboxylic acid, bicyclo[2.2.1]heptanes-1-carboxylic acid and bicyclo[2.2.2]octane-1-carboxylic acid; oxygen-containing fatty acids such as acetoacetic acid, ethoxyacetic acid, glyoxylic acid, glycolic acid, gluconic acid, sabinic acid, 2-hydroxytetradecanoic acid, ipurolic acid, 2,2-dimethyl-3-hydroxypropionic acid, 2-hydroxyhexadecanoic acid, jalapinic acid, juniperic acid, ambrettolic acid, aleuritic acid, 2-hydroxyoctadecanoic acid, 12-hydroxyoctadecanoic acid, 18-hydroxyoctadecanoic acid, 9,10-dihydroxyoctadecanoic acid, ricinolic acid, camlolenic acid, licanic acid, pheronic acid, cerebronic acid and 2-methyl-7-oxabicyclo[2.2.1]-5-heptene-2-carboxylic acid; and halogen-substituted monocarboxylic acids such as chloroacetic acid, 2-chloroacrylic acid and chlorobenzoic acid. As far as aliphatic dicarboxylic acids are concerned, there may be mentioned saturated dicarboxylic acids such as adipic acid, azelaic acid, pimelic acid, suberic acid, sebacic acid, ethylmalonic acid, glutaric acid, oxalic acid, malonic acid, succinic acid, oxydiacetic acid, dimethylmalonic acid, ethylmethylmalonic acid, diethylmalonic acid, 2,2-dimethylsuccinic acid, 2,2-diethylsuccinic acid, 2,2-dimethylglutaric acid and 1,2,2-trimethyl-1,3-cyclopentanedicarboxylic acid; and unsaturated dicarboxylic acids such as maleic acid, fumaric acid, acetylenedicarboxylic acid and itaconic acid. As far as aliphatic polycarboxylic acids are concerned, there may be mentioned tricarboxylic acids such as aconitic acid, 4,4-dimethylaconitic acid, citric acid, isocitric acid and 3-methylisocitric acid. As aromatic carboxylic acids, there may be mentioned aromatic monocarboxylic acids such as benzoic acid, 9-anthracenecarboxylic acid, atrolactic acid, anisic acid, isopropylbenzoic acid, salicylic acid and toluic acid; and aromatic polycarboxylic acids such as phthalic acid, isophthalic acid, terephthalic acid, carboxyphenylacetic acid and pyromellitic acid.

[0190] The phenol used as a promoter is not particularly restricted but includes, for example, monovalent phenols such as phenol, o-cresol, m-cresol, p-cresol, 2-isopropylphenol, 2-tert-butylphenol, 2-sec-butylphenol, 4-tert-butylphenol, 4-sec-butylphenol, 2-aminophenol, 4-cumylphenol, 3,5-dimethylphenol, 2,3,6-tributylphenol, and styrenated phenol; and polyvalent phenols such as catechol, resorcinol, hydroquinone, pyrogallol, and tannic acid.

[0191] The combined use of these promoters is expected to enhance the catalytic activity of the guanidine compound (B-1) and thus improve the curability and depth curability of the curable composition.

[0192] Among the promoters mentioned above, lauric acid, neodecanoic acid, salicylic acid, phenol, and o-cresol are preferred, neodecanoic acid and phenol are more preferred, and neodecanoic acid is still more preferred, since they further enhance the surface curability of the organic polymer (A) and are readily available.

[0193] When the carboxylic acid is added, the addition level thereof is preferably 0.01 to 20 parts by weight, more

preferably 0.1 to 10 parts by weight, and still more preferably 1 to 5 parts by weight, per 100 parts by weight of the (A) component organic polymer.

[0194] The curable composition of the present invention essentially comprises a plasticizer (hereinafter, also referred to as a "plasticizer (c)") as a (c) component. The plasticizer (c) functions as an agent for adjusting the viscosity and slump characteristics of the curable composition and adjusting the tensile strength, elongation and like mechanical characteristics (tensile strength, elongation characteristics, and the like) of the cured products obtained.

[0195] While the plasticizer to be incorporated in the curable composition may comprise one single compound species or a combination of a plurality of species, it is essential that a non-phthalate ester type plasticizer account for at least 80% by weight of the amount of the plasticizer (C).

[0196] This is a measure taken to solve the problem that when a phthalate ester type plasticizer such as dibutyl phthalate, diheptyl phthalate, di(2-ethylhexyl) phthalate and butylbenzyl phthalate is incorporated in the curable composition of the invention, the curability of the curable composition lowers with ease upon storage as the addition level of the phthalate ester type plasticizer increases.

[0197] The above-mentioned decrease in curability is presumably caused by the progress of the transesterification reaction between the high-activity reactive silyl group represented by the general formula (1) and the phthalate ester type plasticizer during storage, with the result that a low-activity alkoxysilyl group-containing organic polymer is formed in the composition and, accordingly, the organic polymer (A) containing the high-activity reactive group of general formula (1) decreases.

[0198] Therefore, the proportion of the phthalate ester type plasticizer in the plasticizer (C) is preferably as low as possible; it is necessary that a non-phthalate ester type plasticizer account for at least 80% by weight of the amount of the plasticizer (C). It is preferred that a non-phthalate ester type plasticizer account for at least 85% by weight, more preferably at least 90% by weight, particularly preferably 100% by weight, of the amount of the plasticizer (C).

[0199] When 80 to 100% by weight of the amount of the plasticizer (C) is accounted for by a non-phthalate ester type plasticizer, it is possible to obtain curable compositions capable of retaining the curability owing to the guanidine compound (B-1), which is the silanol condensation catalyst, even after storage.

[0200] The "non-phthalate ester type plasticizer", so referred to herein, is a plasticizer which has no phthalate ester structure in a molecule. The non-phthalate ester type plasticizer is not particularly restricted but includes: nonaromatic dibasic acid esters such as dioctyl adipate, dioctyl sebacate, dibutyl sebacate and diisodecyl succinate; aliphatic esters such as butyl oleate and methyl acetylricinoleate; phosphoric acid esters such as tricresyl phosphate and tributyl phosphate; trimellitic acid esters; chlorinated paraffins; hydrocarbon type oils such as alkylidiphenyls and partially hydrogenated terphenyl; process oils; and epoxy type plasticizers such as epoxidized soybean oil and benzyl epoxystearate.

[0201] As the plasticizer (c), a polymeric plasticizer containing a polymer component in the molecule, which has a molecular weight of not less than 500, is preferred since such addition makes it possible to maintain the initial characteristics of the cured products obtained for a long period of time

and, further, improve the drying characteristics (also referred to as applicability) of an alkyd paint when it is applied to the cured products obtained.

[0202] The polymeric plasticizer is not particularly restricted but includes: vinyl polymers obtained by polymerization of vinyl monomers by various methods; polyalkylene glycol esters such as diethylene glycol dibenzoate, triethylene glycol dibenzoate and pentaerythritol esters; polyester type plasticizers derived from a dibasic acid such as sebacic acid, adipic acid, azelaic acid and phthalic acid and a dihydric alcohol such as ethylene glycol, diethylene glycol, triethylene glycol, propylene glycol and dipropylene glycol; polyether polyols such as polyethylene glycol, polypropylene glycol and polytetramethylene glycol, each having a molecular weight of not lower than 500, preferably not lower than 1000, or polyether derivatives derived from such polyether polyols by esterification or etherification of one or both hydroxyl groups therein; polystyrenes such as polystyrene and poly- α -methylstyrene; polybutadiene, polybutene, polyisobutylene, butadiene-acrylonitrile copolymers, polychloroprene and the like.

[0203] The polymeric plasticizer is preferably used in combination with the guanidine compound (B-1) since it is possible to obtain curable compositions in which the curability tends not to be reduced even after storage.

[0204] Among these polymeric plasticizers, those highly compatible with the organic polymer (A) are preferred and, for example, polyethers and vinyl polymers may be mentioned. Polyethers are more preferred since they provide the curable composition with good surface curability and depth curability and cause no curing retardation after storage; more specifically, polypropylene glycol is particularly preferred.

[0205] Further, vinyl polymers are preferred since they have high compatibility with the organic polymer (A) and provide the resulting cured products with good weather resistance and thermal stability; among them, acrylic polymers and/or methacrylic polymers are more preferred, and such acrylic polymers as polyacrylic acid alkyl esters are particularly preferred.

[0206] While the method of producing the polyacrylic acid alkyl esters is not particularly restricted, the living radical polymerization method is preferred because of capability of their giving polymers narrow in molecular weight distribution and possibly low in viscosity, and the atom transfer radical polymerization method is more preferred. Also particularly preferred is the method called "SGO process" and disclosed in Japanese Kokai Publication 2001-207157, which comprises continuously bulk-polymerizing an acrylic acid alkyl ester type compound under high temperature and high pressure conditions.

[0207] The number average molecular weight of the polymeric plasticizer is generally 500 to 15000, preferably 800 to 10000, more preferably 1000 to 8000, particularly preferably 1000 to 5000, most preferably 1000 to 3000. When the molecular weight of the polymeric plasticizer is too low, the plasticizer may escape from the cured products obtained with the lapse of time due to heat or rainfall and, as a result, it becomes no longer possible to maintain the initial physical characteristics, staining by adhesion of dust may possibly be caused and the alkyd applicability tends to become poor. On the other hand, when the molecular weight is excessively high, the viscosity of the curable composition will increase and the workability tends to become poor.

[0208] The molecular weight distribution of the polymeric plasticizer is not particularly restricted but preferably is narrow, for example narrower than 1.80, preferably not wider than 1.70, more preferably not wider than 1.60, still more preferably not wider than 1.50, particularly preferably not wider than 1.40, most preferably not wider than 1.30.

[0209] In the case of polyether type polymers, the number average molecular weight is determined by the end-group analysis and, in the case of other polymers, it is determined by the GPC method. The molecular weight distribution (M_w/M_n) is measured by the GPC method (on the polystyrene equivalent basis).

[0210] The polymeric plasticizer may be a reactive silyl group-containing one or a silyl group-free one and, in cases where a reactive silyl group-containing polymeric plasticizer is added, the polymeric plasticizer is preferably involved in the curing reaction and thus, the plasticizer can be prevented from migrating from the cured products obtained.

[0211] The reactive silyl group-containing polymeric plasticizer is preferably a compound whose silyl group content is, on an average, not more than one, preferably not more than 0.8, per molecule. When a reactive silyl group-containing plasticizer, in particular a reactive silyl group-containing oxyalkylene polymer, is added, it is preferred that the number average molecular weight thereof be lower than that of the organic polymer (A) so that a satisfactory plasticizing effect may be obtained.

[0212] The plasticizer (c) to be added may comprise a single species or a combination of a plurality of species as mentioned above. It is also possible to add a low-molecular-weight plasticizer and a polymeric plasticizer in combination. The plasticizer addition may also be made on the occasion of the production of the organic polymer (A).

[0213] The plasticizer (C) preferably has a pour point of not higher than 20° C., more preferably not higher than 0° C., particularly preferably not higher than -20° C., most preferably not higher than -40° C., as measured according to JIS K 2269. When the pour point is higher than 20° C., the curable composition easily freezes in the winter season and the workability tends to become reduced.

[0214] the addition level of the plasticizer (c) is preferably 5 to 150 parts by weight, more preferably 10 to 120 parts by weight, particularly preferably 20 to 100 parts by weight, per 100 parts by weight of the organic polymer (A). At addition levels lower than 5 parts by weight, there is a tendency for the plasticizing effect to be little produced and, at levels exceeding 150 parts by weight, there arises a tendency for the mechanical strength of the cured products to become insufficient.

[0215] In the curable composition of the present invention, there is incorporated an adhesiveness-imparting agent, if necessary.

[0216] The adhesiveness-imparting agent is a compound containing a hydrolyzable silyl group and other functional group(s) in the molecule and, when incorporated into the curable composition, effectively improves the adhesiveness of the resulting cured products to various adherends and/or effectively removes (dehydrates) the moisture contained in the curable composition. Further, the adhesiveness-imparting agent is a compound capable of not only producing the effects mentioned above but also functioning as a physical property modifier and/or a dispersibility-improving agent for inorganic fillers.

[0217] The hydrolyzable silyl group occurring in the adhesiveness-imparting agent includes the groups represented by the general formula (1): $-\text{SiX}_3$ and the general formula (6): $-\text{SiR}^{14}_n\text{X}_{3-n}$, with each X being a hydrolyzable group, and may be any of those enumerated hereinabove as examples of the hydrolyzable group.

[0218] Among those, a methoxy group, an ethoxy group, and the like are preferred because of their proper rate of hydrolysis. The number of hydrolyzable groups contained in each molecule of the adhesiveness-imparting agent is preferably not smaller than 2, particularly preferably not smaller than 3.

[0219] As examples of the functional group other than the hydrolyzable silyl group as occurring in the adhesiveness-imparting agent, there may be mentioned a substituted or unsubstituted amino group, mercapto group, epoxy group, carboxyl group, vinyl group, isocyanato group and isocyanurate group, and halogen atoms. In particular, substituted or unsubstituted amino group-containing adhesiveness-imparting agents are preferred since they show good compatibility with the guanidine compound (B-1) and the like. Substituted or unsubstituted amino group-containing adhesiveness-imparting agents are preferred also in view of their ability to enhance the adhesiveness between the cured products obtained and adherends.

[0220] The adhesiveness-imparting agent is not particularly restricted but includes aminosilanes such as γ -aminopropyltrimethoxysilane, γ -aminopropyltriethoxysilane, γ -aminopropyltriisopropoxysilane, γ -aminopropylmethyldimethoxysilane, γ -aminopropylmethyldiethoxysilane, γ -(2-aminoethyl)aminopropyltrimethoxysilane, γ -(2-aminoethyl)aminopropylmethyldimethoxysilane, γ -(2-aminoethyl)aminopropyltriethoxysilane, γ -(2-aminoethyl)aminopropylmethyldiethoxysilane, γ -(2-aminoethyl)aminopropyltriisopropoxysilane, γ -(2-aminoethyl)aminoethylaminopropyltrimethoxysilane, γ -(6-aminoethyl)aminopropyltrimethoxysilane, 3-(N-ethylamino)-2-methylpropyltrimethoxysilane, 2-aminoethylaminomethyltrimethoxysilane, N-cyclohexylaminomethyltriethoxysilane, N-cyclohexylaminomethyldiethoxymethylsilane, γ -ureidopropyltrimethoxysilane, γ -ureidopropyltriethoxysilane, N-phenyl- γ -aminopropyltrimethoxysilane, N-phenylaminomethyltrimethoxysilane, N-benzyl- γ -aminopropyltrimethoxysilane, N-vinylbenzyl- γ -aminopropyltriethoxysilane, N-(3-triethoxysilylpropyl)-4,5-dihydroimidazole, N-cyclohexylaminomethyltriethoxysilane, N-cyclohexylaminomethyldiethoxymethylsilane, N-phenylaminomethyltrimethoxysilane, (2-aminoethyl)aminomethyltrimethoxysilane and N,N'-bis[3-(trimethoxysilyl)propyl]ethylenediamine; ketimine type silanes such as N-(1,3-dimethylbutylidene)-3-(triethoxysilyl)-1-propanamine, and condensation products resulting from partial condensation of the silanes mentioned above.

[0221] Among the adhesiveness-imparting agents mentioned above, γ -aminopropyltrimethoxysilane is particularly preferred from the viewpoints of compatibility, transparency and availability.

[0222] The adhesiveness-imparting agent to be incorporated in the curable composition may comprise a single species or a combination of a plurality of species. In selecting the adhesiveness-imparting agent, it is preferred that one containing a hydrolyzable group of the same structure as the hydrolyzable group occurring in the organic polymer (A) so that the

surface curability of the curable composition may be prevented from changing during storage. Thus, when the hydrolyzable silyl group in the organic polymer (A) is a methoxysilyl group, an adhesiveness-imparting agent with a methoxysilyl group structure should be selected and, when the hydrolyzable silyl group in the organic polymer (A) is an ethoxysilyl group, an adhesiveness-imparting agent with an ethoxysilyl group structure should be selected.

[0223] To the curable composition of the present invention, there is added a filler, if necessary. The filler is not particularly restricted but includes: reinforcing fillers such as fumed silica, precipitated silica, crystalline silica, fused silica, dolomite, silicic anhydride, hydrous silicic acid and carbon black; heavy calcium carbonate, colloidal calcium carbonate, magnesium carbonate, diatomaceous earth, calcined clay, clay, talc, titanium oxide, bentonite, organic bentonite, ferric oxide, fine aluminum powder, flint powder, zinc oxide, activated zinc white, shirasu balloons, glass microballoons, organic microballoons based on a phenol resin or a vinylidene chloride resin, organic powders such as PVC powder and PMMA powder; and fibrous fillers such as asbestos, glass fibers and filaments.

[0224] When a filler is added, the addition level thereof is preferably 1 to 250 parts by weight, more preferably 10 to 200 parts by weight, per 100 parts by weight of the organic polymer (A).

[0225] On the occasion of using the curable composition as a one-pack type adhesive or sealant, it is preferred, for obtaining good storage stability, that such a filler as mentioned above be uniformly mixed with a dehydrating agent such as calcium oxide and the mixture be allowed to stand in a sealed bag made of an airtight material for a proper period of time for dehydrating and drying, and then used, as disclosed in Japanese Kokai Publication 2001-181532 and the like.

[0226] When the cured products obtained are to be used in the fields of application where transparency is required, a polymer powder containing a polymer of methyl methacrylate and the like, and noncrystalline silica, are preferred as the filler to be added, as disclosed in Japanese Kokai Publication H11-302527 and the like; hydrophobic silica and the like, as disclosed in Japanese Kokai Publication 2000-38560 and the like, is more preferred.

[0227] The hydrophobic silica, so referred to herein, is a product derived by treating the surface of the silicon dioxide fine powder generally occupied by silanol ($-\text{SiOH}$) groups with an organosilicon halide or an alcohol for conversion of those groups to ($-\text{SiO}-$ hydrophobic) groups. The hydrophobic silica is not particularly restricted but includes, for example, products obtained by treating silanol groups occurring on a silicon dioxide fine powder with dimethylsiloxane, hexamethyldisilazane, dimethyldichlorosilane, trimethoxyoctylsilane, trimethylsilane, and the like. The untreated silicon dioxide fine powder whose surface is occupied by silanol ($-\text{SiOH}$) groups is called hydrophilic silica fine powder.

[0228] When the cured products obtained are to be used in the fields of application where high strength is required, silicon compounds such as fumed silica, precipitated silica, crystalline silica, fused silica, dolomite, silicic anhydride and hydrous silicic acid; carbon black, surface-treated finely divided calcium carbonate, calcined clay, clay, activated zinc white and the like are preferred as the filler to be added, and the addition level thereof is preferably 1 to 200 parts by weight per 100 parts by weight of the organic polymer (A).

[0229] Further, when the cured products obtained are to be used in the fields of application where low strength and high elongation modulus are required, titanium oxide, calcium carbonate such as heavy calcium carbonate, magnesium carbonate, talc, ferric oxide, zinc oxide and shirasu balloons are preferred as the filler to be added, and the addition level thereof is preferably 5 to 200 parts by weight per 100 parts by weight of the organic polymer (A).

[0230] When calcium carbonate is added, the tendency toward improvements in the breaking strength, breaking elongation and adhesiveness of the cured products obtained increases as the specific surface area increases. Only one of these filler species may be added or a plurality of species thereof may be added in combination.

[0231] The example of addition of a plurality of additives is not particularly restricted but the combined use of a surface-treated fine calcium carbonate and a calcium carbonate larger in particle diameter such as heavy calcium carbonate is preferred since cured products excellent in physical characteristics can be obtained.

[0232] The surface-treated fine calcium carbonate is a calcium carbonate species obtained by treatment of the particle surface with one or a combination of fatty acids, fatty acid salts, resin acids, other organic carboxylic acids and organic carboxylic acid salts, surfactants and the like so as to increase the lipophilicity of the surface for dispersibility improvement; it has a particle diameter of not greater than 0.5 μm .

[0233] Preferred among the surface-treated fine calcium carbonate species are those treated with a fatty acid or a fatty acid salt since they increase the activity of the guanidine compound (B-1) and thereby enhance the surface curability and depth curability of the curable composition obtained.

[0234] Preferred as the calcium carbonate having a large particle diameter are those whose particle diameter is not smaller than 1 μm and whose particle surface has not been treated.

[0235] In cases where the curable composition is required to have good workability (releasability, etc.) or where the surface of the cured products obtained is required to be matted, organic balloons or inorganic balloons are preferred as the filler to be added. These fillers may be surface-treated or non-surface-treated, and only one species thereof may be added or a plurality of species thereof may be added in admixture. For improving the workability (releasability, etc.), the particle diameter of the balloons is preferably not larger than 0.1 mm and, for rendering the cured product surface matted, it is preferably 5 to 300 μm .

[0236] The curable composition of the present invention, which gives cured products excellent in chemical resistance, is suited for use, in particular, as a sealant, adhesive or like composition for siding boards in ceramic and like systems and for housing outside-wall joints and outside-wall tiles.

[0237] On the occasion of use in such fields of application, the cured products obtained appear or exist on the joints or like observable surfaces and, therefore, it is desirable that the cured product design be in harmony with the outside wall design. In recent years, in particular, the sputtering coating and the addition of colored aggregates, among others, have been employed for providing luxurious outside walls, so that the designs of cured products are becoming more and more important.

[0238] For obtaining luxurious designs, a scaly or granular substance is incorporated in the curable composition of the present invention. The addition of a granular substance gives

sandy or sandstone-like rough surfaces, and the addition of a scaly substance gives surfaces rendered uneven due to scales.

[0239] The cured products obtained are in harmony with luxurious outside walls and are excellent in chemical resistance, so that the luxurious appearance thereof can be maintained for a long period of time.

[0240] The scaly or granular substance is not particularly restricted but includes, for example, one disclosed in Japanese Kokai Publication H09-53063, and the diameter thereof is properly selected according to the outside wall material and design and is preferably not smaller than 0.1 mm, more preferably 0.1 to 5.0 mm. In the case of a scaly substance, the thickness of scales is preferably $\frac{1}{10}$ to $\frac{1}{5}$ (0.01 to 1.00 mm) of the diameter.

[0241] When the scaly or granular substance is added, the addition level thereof is properly selected according to the size of the scaly or granular substance, the outside-wall material and design and other factors; preferably, the addition level is 1 to 200 parts by weight per 100 parts by weight of the curable composition.

[0242] The material of the scaly or granular substance is not particularly restricted but includes natural products such as silica sand and mica, synthetic rubbers, synthetic resins, and inorganic materials such as alumina. These may be appropriately colored according to the outside wall material, design, and so forth so that the design quality of the composition applied to joints and so forth may be enhanced.

[0243] Preferred methods of finishing are those disclosed in Japanese Kokai Publication H09-53063 and the like.

[0244] The scaly or granular substance may be incorporated in advance in the curable composition or may be admixed with the curable composition of the occasion of use thereof.

[0245] It is also possible, for the same purposes, to add balloons (preferably having an average particle diameter of not smaller than 0.1 mm) to the curable composition, thereby providing the resulting cured product surface with a coarse feel such as a sandy or sandstone feel and, further, contributing to weight reduction. The "balloons" are spherical hollow fillers.

[0246] The balloons are not particularly restricted but include, for example, those disclosed in Japanese Kokai Publications H10-251618, H02-129262, H04-8788, H04-173867, H05-1225, H07-113073, H09-53063, 2000-154368 and 2001-164237 and WO 97/05201.

[0247] As the material of balloons, there may be mentioned inorganic materials such as glass, shirasu and silica; and organic materials such as phenol resins, urea resins, polystyrene and Saran. Mention may further be made of composite materials of an inorganic material and an organic material; and laminates comprising a plurality of layers. These may be used singly or a plurality species thereof may be used in combination.

[0248] It is also possible to use balloons subjected to surface coating treatment, treatment with various surface treatment agents or some other treatment; as typical examples, there may be mentioned organic balloons coated with calcium carbonate, talc, titanium oxide or the like, and inorganic balloons surface-treated with an adhesiveness-imparting agent.

[0249] Further, the balloons preferably have a particle diameter of not smaller than 0.1 mm, more preferably 0.2 mm to 5.0 mm, particularly preferably 0.5 mm to 5.0 mm. When the diameter is smaller than 0.1 mm, the addition even in large

amounts only increases the viscosity of the composition, sometimes failing to provide the resulting cured products with a coarse feel.

[0250] The addition level of the balloons can be properly selected according to the intended decorative effect; it is preferred that balloons having a particle diameter of not smaller than 0.1 mm be added in an amount such that the volume concentration thereof in the curable composition amounts to 5 to 25% by volume, more preferably 8 to 22% by volume. When the volume concentration of balloons is below 5% by volume, the desired coarse feel tends to become lost. At level exceeding 25% by volume, the viscosity of the curable composition increases and the workability thereof tends to become poor; further, the modulus of the cured products increases and the fundamental performance characteristics of the sealant or adhesive tend to become impaired.

[0251] On the occasion of adding balloons, it is also possible to add, in combination, such an anti-slip agent as the one disclosed in Japanese Kokai Publication 2000-154368 or such an amine compound capable of rendering the resulting cured product surface uneven and matted as the one disclosed in Japanese Kokai Publication 2001-164237. Preferred as the amine compound mentioned above are primary and/or secondary amines having a melting point of 35° C. or higher.

[0252] Also usable as the balloons are thermally expandable minute hollow particles disclosed in Japanese Kokai Publication 2004-51701 or 2004-66749, for instance. The “thermally expandable minute hollow particles” are spherical plastic bodies made of a polymer shell material (vinylidene chloride type copolymer, acrylonitrile type copolymer or vinylidene chloride-acrylonitrile copolymer) with a low-boiling compound such as a hydrocarbon containing 1 to 5 carbon atoms as spherically enclosed therein.

[0253] By adding thermally expandable minute hollow particles to the curable composition of the present invention, it becomes possible to obtain, without using any organic solvent at all, a thermally removable adhesive composition which, when no more required, can be peeled off with ease only by heating without destruction of the adherend materials. This is based on the mechanism such that when the adhesive portion is heated, the gas pressure inside the shells of the thermally expandable minute hollow particles increases and the polymer shell material is softened and dramatically expanded to cause peeling at the adhesive interface.

[0254] When the curable composition of the present invention contains sealant curing particles as well, the cured products obtained can have an uneven rough surface and, thus, the decorative feature thereof can be improved. The preferred diameter, addition level, material and the like of the sealant curing particles are disclosed in Japanese Kokai Publication 2001-115142, and the diameter is preferably 0.1 mm to 1 mm, more preferably 0.2 to 0.5 mm. The addition level is preferably 5 to 100 parts by weight, more preferably 20 to 50 parts by weight, per 100 parts by weight of the curable composition.

[0255] The material is not particularly restricted but may be any of the materials used in sealing compositions; thus, mention may be made of urethane resins, silicones, modified silicones and polysulfide rubbers, for example. Among those mentioned above, modified silicone type sealant curing particles are preferred.

[0256] To the curable composition of the present invention, there is added a silicate, if necessary. The silicate acts as a crosslinking agent on the organic polymer (A) and, as a result,

functions to bring about improvements in the restorability, durability and creep resistance of the cured products obtained.

[0257] Further, the addition of a silicate brings about improvements in the adhesiveness and water-resistant adhesiveness and in the bond durability under high-temperature and high-pressure conditions. The silicate is not particularly restricted but includes, for example, tetraalkoxysilanes or partial hydrolysis condensation products derived therefrom; more specifically, there may be mentioned tetraalkoxysilanes (tetraalkyl silicates) such as tetramethoxysilane, tetraethoxysilane, ethoxytrimethoxysilane, dimethoxydiethoxysilane, methoxytriethoxysilane, tetra-n-propoxysilane, tetra-1-propoxysilane, tetra-n-butoxysilane, tetra-1-butoxysilane and tetra-t-butoxysilane as well as partial hydrolysis condensation products derived therefrom.

[0258] The addition level of the silicate is preferably 0.1 to 20 parts by weight, more preferably 0.5 to 10 parts by weight, per 100 parts by weight of the organic polymer (A).

[0259] The tetraalkoxysilane-derived partial hydrolysis condensation product is not particularly restricted but includes, for example, products derived from tetraalkoxysilanes by addition of water thereto to cause partial hydrolysis and condensation.

[0260] The addition of a tetraalkoxysilane-derived partial hydrolysis condensation product is preferred since such condensation product produces significant improvements in restorability, durability and creep resistance of the cured products obtained as compared with the corresponding composition containing the tetraalkoxysilane added thereto.

[0261] Commercially available as the tetraalkoxysilane-derived partial hydrolysis condensation product are, for example, Methyl Silicate 51 and Ethyl Silicate 40 (both being products of Colcoat Co., Ltd.); these can be used as additives.

[0262] For the purpose of inhibiting the surface curability of the curable composition from changing during storage, it is preferred that the silicate be selected from among those in which the silicon atom-bound hydrolyzable groups are the same as the hydrolyzable groups in the reactive silyl group occurring in the organic polymer (A). Thus, when the organic polymer (A) contains methoxysilyl groups, a methoxysilyl group-containing silicate is preferably selected and, when the organic polymer (A) contains ethoxysilyl groups, an ethoxysilyl group-containing silicate is preferably selected.

[0263] The addition of a polymeric plasticizer containing a polymer constituent within the molecule is preferred since such makes it possible, for example, for the cured products obtained to retain their initial characteristics for a long period and for the cured products obtained to be improved in drying characteristics (also referred to as coatability) when coated with an alkyd paint.

[0264] The polymeric plasticizer is not particularly restricted but includes: vinyl polymers obtained by polymerization of vinyl monomers by various methods; polyalkylene glycol esters such as diethylene glycol dibenzoate, triethylene glycol dibenzoate and pentaerythritol esters; polyester type plasticizers derived from a dibasic acid such as sebacic acid, adipic acid, azelaic acid and phthalic acid and a dihydric alcohol such as ethylene glycol, diethylene glycol, triethylene glycol, propylene glycol and dipropylene glycol; polyether polyols such as polyethylene glycol, polypropylene glycol and polytetramethylene glycol, each having a molecular weight of not lower than 500, preferably not lower than 1000, or polyether derivatives derived from such polyether polyols

by esterification or etherification of one or both hydroxyl groups therein; polystyrenes such as polystyrene and poly- α -methylstyrene; polybutadiene, polybutene, polyisobutylene, butadiene-acrylonitrile copolymers, polychloroprene and the like.

[0265] In the curable composition of the invention, there is incorporated a tackifier, if necessary.

[0266] The tackifier is not particularly restricted provided that it is one in common use, irrespective of whether it occurs as a solid or liquid at ordinary temperature. For example, there may be mentioned styrene block copolymers, hydrogenation products derived therefrom, phenol resins, modified phenol resins (e.g. cashew oil-modified phenol resins, tall oil-modified phenol resins), terpene-phenol type resins, xylene-phenol type resins, cyclopentadiene-phenol type resins, coumarone-indene type resins, rosin type resins, rosin ester type resins, hydrogenated rosin ester type resins, xylene type resins, low-molecular-weight polystyrene type resins, styrene copolymer resins, petroleum resins (e.g. C5 hydrocarbon type resins, C9 hydrocarbon type resins, C5C9 hydrocarbon copolymer resins), hydrogenated petroleum resins, terpene type resins, DCPD resins, and petroleum resins. These may be added singly or a plurality thereof may be added in combination.

[0267] The styrene block copolymers and hydrogenation products derived therefrom mentioned above are not particularly restricted but include, for example, styrene-butadiene-styrene block copolymers (SBSs), styrene-isoprene-styrene block copolymers (SISs), styrene-ethylenebutylene-styrene block copolymers (SEBSs), styrene-ethylenepropylene-styrene block copolymers (SEPSs) and styrene-isobutylene-styrene block copolymers (SIBSs).

[0268] When a tackifier is added, the addition level thereof is preferably 5 to 1,000 parts by weight, more preferably 10 to 100 parts by weight, per 100 parts by weight of the organic polymer (A).

[0269] In the curable composition of the present invention, there is incorporated a solvent or diluent, if necessary.

[0270] The solvent or diluent is not particularly restricted but includes, for example, aliphatic hydrocarbons, aromatic hydrocarbons, alicyclic hydrocarbons, halogenated hydrocarbons, alcohols, esters, ketones and ethers. These may be added singly or a plurality thereof may be added in combination.

[0271] When a solvent or diluent is added, the solvent or diluent preferably has a boiling point of 150° C. or higher, more preferably 200° C. or higher, so that the volatile components in the solvent or diluent may be inhibited from dissipating into the air on the occasion of indoor use of the curable composition.

[0272] In the curable composition of the present invention, there may be incorporated a physical property modifier, if necessary. The physical property modifier functions so as to adjust the tensile characteristics and hardness of the resulting cured products.

[0273] The physical property modifier is not particularly restricted but includes, for example, alkylalkoxysilanes such as methyltrimethoxysilane, dimethyldimethoxysilane, trimethylmethoxysilane and n-propyltrimethoxysilane; alkylisopropenoxysilanes such as dimethyldiisopropenoxysilane, methyltriisopropenoxysilane and γ -glycidoxypropylmethyldiisopropenoxysilane; functional group-containing alkoxysilanes such as γ -glycidoxypropylmethyldimethoxysilane, γ -glycidoxypropyltrimethoxysilane, vinyltrimethoxysilane,

vinyltrimethoxysilane, γ -aminopropyltrimethoxysilane, N-(β -aminoethyl)aminopropylmethyldimethoxysilane, γ -mercaptopropyltrimethoxysilane and γ -mercaptopropylmethyldimethoxysilane; silicone varnishes; and polysiloxanes. These may be added singly or a plurality thereof may be added in admixture.

[0274] Among such physical property modifiers, those which form, upon hydrolysis, a compound containing a monovalent silanol group in the molecule are preferred since they are effective in reducing the modulus of the resulting cured products without worsening the surface stickiness thereof; among them, those which form, upon hydrolysis, trimethylsilanol are more preferred.

[0275] The compounds which form, upon hydrolysis, a compound containing monovalent silanol group in the molecule are not particularly restricted but include: those compounds disclosed in Japanese Kokai Publication H05-117521; compounds derived from an alkyl alcohol, such as hexanol, octanol and decanol, and capable of forming, upon hydrolysis, such an organosilicon compound represented by R_3SiOH as trimethylsilanol; and those compounds disclosed in Japanese Kokai Publication H11-241029 which are compounds derived from a polyhydric alcohol containing 3 or more hydroxyl groups in each molecule, for example trimethylolpropane, glycerol, pentaerythritol or sorbitol, and capable of forming, upon hydrolysis, such an organosilicon compound represented by R_3SiOH as trimethylsilanol.

[0276] Further, mention may be made of those compounds disclosed in Japanese Kokai Publication H07-258534 which are derived from an oxypropylene polymer and capable of forming, upon hydrolysis, such an organosilicon compound represented by R_3SiOH as trimethylsilanol and, further, those compounds disclosed in Japanese Kokai Publication H06-279693 which contain a crosslinkable hydrolyzable silyl group and a silyl group capable of forming, upon hydrolysis, a monovalent silanol group-containing compound.

[0277] When a physical property modifier is added, the addition level thereof is preferably 0.1 to 20 parts by weight, more preferably 0.5 to 10 parts by weight, per 100 parts by weight of the organic polymer (A).

[0278] In the curable composition of the present invention, there may be incorporated a thixotropic agent (anti-sagging agent), if necessary. The term "thixotropic agent" refers to an agent functioning to prevent the curable composition from sagging and improve the workability thereof.

[0279] The thixotropic agent is not particularly restricted but includes, for example, polyamide waxes; hydrogenated castor oil derivatives; and metal soaps such as calcium stearate, aluminum stearate and barium stearate. Further, mention may be made of those rubber powders having a particle diameter of 10 to 500 μm which are disclosed in Japanese Kokai Publication H₁₁-349916, and those organic fibers disclosed in Japanese Kokai Publication 2003-155389.

[0280] These thixotropic agents (antisagging agents) may be added singly or a plurality of species may be added in combination.

[0281] When a thixotropic agent is added, the addition level thereof is preferably 0.1 to 20 parts by weight per 100 parts by weight of the organic polymer (A).

[0282] In the curable composition of the present invention, there is incorporated, for example, a compound containing an epoxy group in each molecule, if necessary. By adding an epoxy group-containing compound, it becomes possible to enhance the restorability of the cured products obtained.

[0283] The epoxy group-containing compound is not particularly restricted but includes, for example, epoxidized unsaturated fats and oils; epoxidized unsaturated fatty acid esters; alicyclic epoxy compounds; epichlorohydrin derivatives and like compounds; and mixtures thereof. More specifically, there may be mentioned epoxidized soybean oil, epoxidized linseed oil, bis(2-ethylhexyl)-4,5-epoxycyclohexane-1,2-dicarboxylate (E-PS), epoxyoctyl stearate, epoxylbutyl stearate and the like. Among these, E-PS is preferred.

[0284] When an epoxy compound is added, the addition level thereof is preferably 0.5 to 50 parts by weight per 100 parts by weight of the organic polymer (A).

[0285] In the curable composition of the present invention, there is added a photocurable substance, if necessary. The photocurable substance is a substance capable of undergoing, under the action of light, chemical changes in molecular structure in a short period of time which lead to changes in physical properties such as curing. The addition of a photocurable substance to the curable composition results in the formation of a photocurable substance-based layer on the surface of the cured products obtained and thus in improvements in the stickiness and weather resistance of the cured products.

[0286] The photocurable substance is not particularly restricted but includes those known in the art, such as organic monomers, oligomers, resins, and compositions containing any of them; for example, there may be mentioned unsaturated acrylic compounds, vinyl cinnamate polymers and azidized resins.

[0287] As the unsaturated acrylic compounds, there may be mentioned monomers, oligomers, or mixtures thereof, containing one or a plurality of acrylic or methacrylic unsaturated groups in each molecule, and, specifically, propylene (or butylene or ethylene) glycol di(meth)acrylate, neopentyl glycol di(meth)acrylate and like monomers or oligomers having a molecular weight not exceeding 10,000. More specifically, there may be mentioned, for example, such special acrylates as (bifunctional) Aronix M-210, Aronix M-215, Aronix M-220, Aronix M-233, Aronix M-240 and Aronix M-245; (trifunctional) Aronix M-305, Aronix M-309, Aronix M-310, Aronix M-315, Aronix M-320 and Aronix M-325, and (polyfunctional) Aronix M-400 (all Aronix products being available from Toagosei Co., Ltd.). Among these, acrylic functional group-containing compounds are preferred, and compounds containing, on an average, 3 or more acrylic functional groups in each molecule are more preferred.

[0288] The vinyl cinnamate polymers are photosensitive resins having cinnamoyl groups as photosensitive groups, which are compounds resulting from esterification of polyvinyl alcohol with cinnamic acid, and many other derivatives of vinyl cinnamate polymers.

[0289] The azidized resins are known as photosensitive resins in which azide groups are photosensitive groups and include rubber photosensitive solutions generally containing a diazide compound added as a photosensitizer and, further, those detailed examples are described in "Kankosei Jushi (Photosensitive Resins)" (published Mar. 1, 1972 by Insatsu Gakkai Shuppanbu Ltd., p. 93 ff., p. 106 ff., and p. 117 ff.). These may be used either singly or in admixture, if necessary together with a sensitizer.

[0290] In some cases, the addition of a sensitizer such as a ketone and nitro compound or a promoter such as an amine enhances the effect.

[0291] When a photocurable substance is added, the addition level thereof is preferably 0.1 to 20 parts by weight, more preferably 0.5 to 10 parts by weight, per 100 parts by weight of the organic polymer (A). At levels of 0.1 part by weight or below, the effect of enhancing the weather resistance of the cured products obtained is very little and, at levels of 20 parts by weight or above, the cured products obtained are too hard, tending to undergo cracking or the like.

[0292] In the curable composition of the present invention, there is incorporated an oxygen-curable substance, if necessary. The oxygen-curable substance can be cured upon reaction with oxygen in the air, and the addition of an oxygen-curable substance makes it possible to reduce the stickiness of the cured product surface and to prevent dirt and dust from adhering to the surface through the formation of a cured layer in the vicinity of the cured product surface obtained.

[0293] The oxygen-curable substance is not particularly restricted but may be any of the compounds containing an unsaturated compound capable of reacting with oxygen in the air; thus, for example, there may be mentioned drying oils such as tung oil and linseed oil, and various alkyd resins obtained by modifying such compounds; drying oil-modified acrylic polymers, epoxy type resins and silicone type resins; liquid polymers obtained by polymerizing or copolymerizing such a diene compound(s) as butadiene, chloroprene, isoprene and 1,3-pentadiene, for example 1,2-polybutadiene, 1,4-polybutadiene and C5-C8 diene polymers; liquid copolymers obtained by copolymerizing such a diene compound with a vinyl compound, such as acrylonitrile and styrene, copolymerizable with the diene compound, in a manner such that the diene compound serve as the main component, for example NBR and SBR; and, further, various modifications thereof (maleinated modifications, boiled oil modifications, etc.). Among those mentioned above, tung oil and liquid diene type polymers are preferred. The oxygen-curable substance to be added may comprise a single species or a combination of a plurality of species.

[0294] When a catalyst and/or metal dryer which are capable of promoting the curing reaction are added in admixture with the oxygen-curable substance, the effect may be enhanced. The catalyst and metal dryer for promoting the curing reaction are not particularly restricted but include, for example, metal salts such as cobalt naphthenate, lead naphthenate, zirconium naphthenate, cobalt octylate and zirconium octylate, and amine compounds.

[0295] When an oxygen-curable substance is added, the addition level thereof is preferably 0.1 to 20 parts by weight, more preferably 0.5 to 10 parts by weight, per 100 parts by weight of the organic polymer (A). At addition levels below 0.1 part by weight, the effect of improving the stain resistance of the cured products obtained tends to become insufficient and, at levels exceeding 20 parts by weight, the tensile characteristics and the like of the cured products obtained tend to become impaired.

[0296] Further, the oxygen-curable substance is preferably added in admixture with a photocurable substance, as disclosed in Japanese Kokai Publication H03-160053.

[0297] In the curable composition of the present invention, there is incorporated an antioxidant, if necessary. By adding an antioxidant, it becomes possible to enhance the thermal stability of the cured products obtained.

[0298] The antioxidant is not particularly restricted but includes hindered phenol type, monophenol type, bisphenol type and polyphenol type antioxidants. Among these, hin-

dered phenol type antioxidants are preferred. Also preferred are hindered amine type light stabilizers such as Tinuvin 622LD and Tinuvin 144; Chimassorb 944 LD and Chimassorb 119FL (all four being products of Chiba Specialty Chemicals); ADK STAB LA-57, ADK STAB LA-62, ADK STAB LA-67, ADK STAB LA-63 and ADK STAB LA-68 (all five being products of Adeka Corporation); and Sanol LS-770, Sanol LS-765, Sanol LS-292, Sanol LS-2626, Sanol LS-1114 and Sanol LS-744 (all six being product of Sankyo Lifetech Co., Ltd.). Specific examples of the antioxidants are disclosed also in Japanese Kokai Publications H04-283259 and H09-194731.

[0299] When an antioxidant is added, the addition level thereof is preferably 0.1 to 10 parts by weight, more preferably 0.2 to 5 parts by weight, per 100 parts by weight of the organic polymer (A).

[0300] In the curable composition of the present invention, there is incorporated a light stabilizer, if necessary. By adding a light stabilizer, the cured products obtained can be prevented from undergoing photooxidative degradation.

[0301] The light stabilizer is not particularly restricted but includes benzotriazole type, hindered amine type and benzozate type compounds. Among these, hindered amine type light stabilizers are preferred.

[0302] When a light stabilizer is added, the addition level thereof is preferably 0.1 to 10 parts by weight, more preferably 0.2 to 5 parts by weight, per 100 parts by weight of the organic polymer (A). A specific example of the light stabilizer is disclosed in Japanese Kokai Publication H09-194731 as well.

[0303] When such a photocurable substance as an unsaturated acrylic compound is added to the curable composition of the present invention, a tertiary amine group-containing hindered amine type light stabilizer is preferably added as disclosed in Japanese Kokai Publication H05-70531 since, then, the storage stability of the curable composition is improved.

[0304] The tertiary amine group-containing hindered amine type light stabilizer is not particularly restricted but includes Tinuvin 622LD, Tinuvin 144 and Chimassorb 119FL (all three being products of Ciba Specialty Chemicals Inc.); ADK STAB LA-57, LA-62, LA-67 and LA-63 (all four being products of Adeka Corporation); and Sanol LS-765, LS-292, LS-2626, LS-1114 and LS-744 (all five being products of Sankyo Lifetech Co., Ltd.).

[0305] To the curable composition of the present invention is added an ultraviolet absorber, if necessary. When an ultraviolet absorber is added to the curable composition, the surface weather resistance of the cured products obtained is improved.

[0306] The ultraviolet absorber is not particularly restricted but includes benzophenone type, benzotriazole type, salicylate type, substituted tolyl type and metal chelate type compounds. Among these, benzotriazole type ultraviolet absorbers are preferred.

[0307] When an ultraviolet absorber is added to the curable composition, the addition level thereof is preferably 0.1 to 10 parts by weight, more preferably 0.2 to 5 parts by weight, per 100 parts by weight of the organic polymer (A).

[0308] The antioxidant, light stabilizer and ultraviolet absorber mentioned above are preferably added in combination to the curable composition and, for example, a phenol or hindered phenol antioxidant, a hindered amine type light stabilizer and a benzotriazole type ultraviolet absorber are preferably added in admixture with the curable composition.

[0309] To the curable composition of the present invention is added a flame retardant, if necessary. The flame retardant is not particularly restricted; thus, for example, phosphorus type flame retardants such as ammonium polyphosphate and tricresyl phosphate; aluminum hydroxide, magnesium hydroxide, and flame retardants such as thermally expandable graphite are added to the curable composition. The flame retardant to be added thereto may comprise a single species or a combination of a plurality of species.

[0310] When a flame retardant is added to the curable composition, the addition level thereof is preferably 5 to 200 parts by weight, more preferably 10 to 100 parts by weight, per 100 parts by weight of the organic polymer.

[0311] To the curable composition of the present invention may be added, if necessary, various additives other than those mentioned above for the purpose of adjusting various physical properties of the curable composition or of the cured products to be obtained. As such additives, there may be mentioned, for example, curability modifiers, radical inhibitors, metal deactivators, antiozonants, phosphorus type peroxide decomposers, lubricants, pigments, blowing agents, antitermites and antifungal agents. Specific examples of these are disclosed in publications such as Japanese Kokoku Publications H04-69659 and H07-108928, and Japanese Kokai Publications S63-254149, S64-22904 and 2001-72854. These additives may be added singly to the curable composition or a plurality thereof may be added in combination to the curable composition.

[0312] In cases where the curable composition is of the one-pack type, the composition contains all components as mixed up in advance and, thus, curing may proceed during storage if moisture is present in formulation components. Therefore, those formulation components which contain moisture are preferably dehydrated and dried prior to addition or dehydrated during compounding and kneading by reducing the pressure, for instance.

[0313] When the curable composition is of the two-pack type, it is not necessary to incorporate the curing catalyst in the main component having a reactive silyl group-containing organic polymer and, therefore, even if some moisture is contained in the formulation components, the risk of the progress of curing (gelation) is low; in cases where long-term storage stability is required, however, it is preferred that the formulation components be dehydrated or dried.

[0314] As for the method of dehydrating or drying, the method comprising drying by heating or the method comprising dehydrating under reduced pressure are preferred in cases where the formulation components are solids such as powders and, in cases where they are liquids, the vacuum dehydration method and the dehydration method using a synthetic zeolite, activated alumina, silica gel, quick lime, magnesium oxide or the like are preferred and, further, the dehydration method comprising adding an alkoxysilane compound such as n-propyltrimethoxysilane, vinyltrimethoxysilane, vinylmethyldimethoxysilane, methyl silicate, ethyl silicate, γ -mercaptopropylmethyldimethoxysilane, γ -mercaptopropylmethyldiethoxysilane and γ -glycidoxypolytrimethoxysilane; an oxazolidine compound such as 3-ethyl-2-methyl-2-(3-methylbutyl)-1,3-oxazolidine; and an isocyanate compound to the curable composition and allowing the same to react with water contained in the formulation components is also preferred. In this way, the storage stability

of the curable composition is improved by the addition of such an alkoxysilane compound, oxazolidine compound and isocyanate compound.

[0315] In using vinyltrimethoxysilane or a like alkoxysilane compound capable of reacting with water for the purpose of drying, the addition level thereof is preferably 0.1 to 20 parts by weight, more preferably 0.5 to 10 parts by weight, per 100 parts by weight of the organic polymer (A).

[0316] The method of preparing the curable composition of the present invention is not particularly restricted but there may be employed, for example, such a method known in the art as a method comprising combining the formulation components mentioned above and kneading the resulting mixture at ordinary temperature or with heating using a mixer, roller, kneader, or the like, or a method comprising dissolving the formulation components using small portions of an appropriate solvent and then mixing up the solutions.

[0317] When exposed to the air, the curable composition of the present invention forms a three-dimensional network structure under the action of atmospheric moisture and thus is cured to give a solid having rubber elasticity.

[0318] The curable composition of the present invention can be suitably used in such fields of application as pressure-sensitive adhesives; sealants for buildings, ships, automobiles, roads, etc.; adhesives; impression materials; vibration-proof materials; damping materials; soundproof materials; expanded/foamed materials; coating compositions; spray coatings, etc. Among such fields of application, the use as sealants or adhesives is more preferred since the cured products obtained are excellent in flexibility and adhesiveness.

[0319] The curable composition of the present invention can also be used in such fields of application as back cover sealants for a solar cell and like electric and electronic part materials; insulating cover materials for electric wires and cables and other electric insulating materials; elastic adhesives; contact adhesives; spray sealants; crack repair materials; tiling adhesives; powder coating compositions; casting materials; rubber materials for medical use; pressure-sensitive adhesives for medical use; sealants for medical devices; food packaging materials; joint sealants for siding boards and other exterior materials; coating materials; primers; electromagnetic wave shielding conductive materials, thermally conductive materials; hot melt materials; potting agents for electrics and electronics; films; gaskets; various molding materials; rustproof and waterproof sealants for wired glass and laminated-glass edges (cut end faces); liquid sealants for use in automotive parts, electrical machinery parts, various machinery parts, etc.

[0320] Further, the curable composition can also be used as various types of hermetically sealants and adhesives since it, either alone or with the aid of a primer, can adhere to a wide range of substrates such as glass, ceramics, wood, metals and resin moldings.

[0321] The curable composition of the present invention can also be used in the form of interior panel adhesives, exterior panel adhesives, tiling adhesives, stone pitching adhesives, ceiling finishing adhesives, floor finishing adhesives, wall finishing adhesives, vehicle panel adhesives, electric, electronic and precision apparatus assembling adhesives, direct glazing sealants, double glazing sealants, sealants for SSG systems, or building working joint sealants.

BEST MODE FOR CARRYING OUT THE INVENTION

[0322] The following examples and comparative examples illustrate the present invention more specifically. These are, however, by no means limitative of the scope of the present invention.

Synthesis Example 1

[0323] Propylene oxide was polymerized using polyoxypropylene diol with a molecular weight of about 2,000 as an initiator and a zinc hexacyanocobaltate glyme complex catalyst to give polypropylene oxide (P-1) having a number average molecular weight of about 25,500 (polystyrene-equivalent molecular weight measured by using a TOSOH model HLC-8120 GPC solvent delivery system, a TOSOH model TSK-GEL H type column, with THF as a solvent). Thereto was then added a methanol solution of NaOMe in an amount of 1.2 equivalents relative to the hydroxyl groups of that hydroxyl-terminated polypropylene oxide (P-1), the methanol was distilled off and, further, allyl chloride was added to the residue for conversion of each terminal hydroxyl group to an allyl group. The unreacted allyl chloride was removed by volatilization under reduced pressure. To 100 parts by weight of the crude allyl-terminated polypropylene oxide obtained were added 300 parts by weight of n-hexane and 300 parts by weight of water and, after mixing with stirring, the water was removed by centrifugation. The hexane solution obtained was further mixed with 300 parts by weight of water with stirring, and after the water was removed again by centrifugation, the hexane was removed by volatilization under reduced pressure. In the above manner, allyl-terminated bifunctional polypropylene oxide (P-2) with a number average molecular weight of about 25,500 was obtained.

[0324] The allyl-terminated polypropylene oxide (P-2) obtained (100 parts by weight) was reacted with 0.95 part by weight of trimethoxysilane at 90° C. for 5 hours in the presence of 150 ppm of an isopropanol solution of a platinum-vinylsiloxane complex (platinum content: 3% by weight) as a catalyst to give a trimethoxysilyl group-terminated polyoxypropylene type polymer (A-1). As a result of ¹H-NMR measurement (made in CDCl₃ solvent using a Nippon Denshi (JEOL Ltd.) model JNM-LA400), the average number of terminal trimethoxysilyl groups per molecule was found to be about 1.3.

Synthesis Example 2

[0325] The allyl-terminated polypropylene oxide (P-2) (100 parts by weight) obtained in Synthesis Example 1 was reacted with 2.1 parts by weight of a 84/16 (in mole ratio) mixture of a silane compound represented by the chemical formula $\text{HSi}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{C}_2\text{H}_4\text{Si}(\text{OCH}_3)_3$ and a silane compound represented by the chemical formula $\text{HSi}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{CH}(\text{CH}_3)\text{Si}(\text{OCH}_3)_3$ at 90° C. for 2 hours in the presence of 150 ppm of an isopropanol solution of platinum-vinylsiloxane complex (platinum content: 3% by weight) as a catalyst to give a dimethyldisiloxane-modified trimethoxysilyl group-terminated polyoxypropylene type polymer (A-2). The trimethoxysilyl group-terminated polyoxypropylene type polymer (A-2) thus obtained contained a group (a) represented by the chemical formula $-\text{Si}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{C}_2\text{H}_4\text{Si}(\text{OCH}_3)_3$ and a group (b) represented by the chemical formula $-\text{Si}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{CH}(\text{CH}_3)\text{Si}(\text{OCH}_3)_3$ and had an a/b ratio value of 84/16 (mole ratio). As a result of

¹H-NMR measurement, the average number of terminal trimethoxysilyl groups per molecule was found to be about 1.2.

Synthesis Example 3

[0326] Propylene oxide was polymerized using, as an initiator, a 1/1 (in weight ratio) mixture of polyoxypropylene diol with a molecular weight of about 2,000 and polyoxypropylene triol with a molecular weight of about 3,000 in the presence of a zinc hexacyanocobaltate glyme complex catalyst to give polypropylene oxide (P-3) having a number average molecular weight of about 19,000 (polystyrene-equivalent molecular weight measured by using a TOSOH model HLC-8120 GPC solvent delivery system, a TOSOH model TSK-GEL H type column, with THF as a solvent).

[0327] Thereto was then added a methanol solution of NaOMe in an amount of 1.2 equivalents relative to the hydroxyl groups of that hydroxyl group-terminated polypropylene oxide (P-3), the methanol was distilled off and, further, allyl chloride was added to the residue for conversion of each terminal hydroxyl group to an allyl group. In the above manner, allyl group-terminated polypropylene oxide (P-4) with a number average molecular weight of about 19,000 was obtained.

[0328] To 100 parts by weight of the crude allyl group-terminated polypropylene oxide (P-4) obtained were added 300 parts by weight of n-hexane and 300 parts by weight of water, and after mixing with stirring, the water was removed by centrifugation. The hexane solution obtained was further mixed with 300 parts by weight of water with stirring, and after the water was removed again by centrifugation, the hexane was removed by vaporization under reduced pressure to give purified allyl group-terminated polypropylene oxide (P-4). The allyl group-terminated polypropylene oxide (P-4) obtained (100 parts by weight) was reacted with 1.35 parts by weight of methyltrimethoxysilane at 90° C. for 5 hours in the presence of 150 ppm of an isopropanol solution of platinum-vinylsiloxane complex (platinum content: 3% by weight) as a catalyst to give a methyltrimethoxysilyl group-terminated polyoxypropylene type polymer (D-1). As a result of ¹H-NMR measurement, the average number of terminal methyltrimethoxysilyl groups per molecule was found to be about 1.7.

Synthesis Example 4

[0329] The allyl-terminated polypropylene oxide (P-2) obtained in Synthesis Example 1 (100 parts by weight) was reacted with 0.80 part by weight of methyltrimethoxysilane at 90° C. for 5 hours in the presence of 150 ppm of an isopropanol solution of platinum-vinylsiloxane complex (platinum content: 3% by weight) as a catalyst to give a methyltrimethoxysilyl group-terminated polyoxypropylene type polymer (D-2). As a result of ¹H-NMR measurement, the average number of terminal methyltrimethoxysilyl groups per molecule was found to be about 1.3.

Example 1

[0330] According to the formulation given in Table 1, 120 parts by weight of surface-treated colloidal calcium carbonate (product of Shiraishi Kogyo Kaisha Ltd., trade name: Hakuenka CCR), 20 parts by weight of titanium oxide (product of Ishihara Sangyo Kaisha Ltd., trade name: Tipaque R-820), 55 parts by weight of a polypropylene glycol type plasticizer having a molecular weight of 3,000 (product of

Mitsui Takeda Chemicals Inc., trade name: Actcol P-23) as the (c) component plasticizer, 2 parts by weight of a thixotropic agent (product of Kusumoto Chemicals Ltd., trade name: Disparlon #6500), 1 part by weight of an ultraviolet absorber (product of Ciba Specialty Chemicals Inc., trade name: Tinuvin 327) and 1 part by weight of a light stabilizer (product of Sankyo Co., Ltd., trade name: Sanol LS770) were weighed and admixed with 100 parts by weight of the trimethoxysilyl group-terminated polyoxypropylene type polymer (A-1) obtained in Synthesis Example 1 and, after thorough kneading, the mixture was passed through a three-roll paint mill for dispersion. Thereafter, the mixture was dehydrated at 120° C. for 2 hours under reduced pressure and, after cooling to a temperature not higher than 50° C., 5 parts by weight of γ -(2-aminoethyl)aminopropyltrimethoxysilane (product of Dow Corning Toray Co., Ltd., trade name: A-1120) as the adhesiveness-imparting agent, 3 parts by weight of γ -glycidoxypolytrimethoxysilane (product of Dow Corning Toray Co., Ltd., trade name: A-187) and 4 parts by weight of 1-(o-tolyl)biguanide (product of Tokyo Chemical Industry Co., Ltd., abbreviated as OTBG) as the (B) component were added and kneaded. After kneading under substantially water-free conditions, the resulting mixture was hermetically packed in a moisture-proof container. A one-pack type curable composition was thus obtained.

Example 2

[0331] A curable composition was obtained in the same manner as in Example 1 except that γ -(2-aminoethyl)aminopropyltrimethoxysilane was used in an amount of 3 parts by weight in lieu of the adhesiveness-imparting agents used in Example 1, and 2 parts by weight of vinyl trimethoxysilane (product of Dow Corning Toray Co., Ltd., trade name: A-171) was added as a dehydrating agent.

Example 3

[0332] A curable composition was obtained in the same manner as in Example 2 except that the organic polymer (A-2) was used in lieu of the organic polymer (A-1) used in Example 2.

Comparative Example 1

[0333] A curable composition was obtained in the same manner as in Example 1 except that OTBG was used in an amount of 10 parts by weight.

Comparative Example 2

[0334] A curable composition was obtained in the same manner as in Example 1 except that the organic polymer (D-1) was used in lieu of the organic polymer (A-1) used in Example 1.

Comparative Example 3

[0335] A curable composition was obtained in the same manner as in Comparative Example 2 except that OTBG was used in an amount of 10 parts by weight.

(Surface Curability)

[0336] Under constant temperature (23° C.) and constant humidity (50%) conditions, each of the above curable compositions was spread to a thickness of about 3 mm, and the surface of the curable composition was touched gently with a

microspatula from time to time and the time required for the composition to become no more sticking to the microspatula was determined. The results thus obtained are shown in Table 1.

(Depth Curability)

[0337] Under constant temperature (23° C.) and constant humidity (50%) conditions, a polyethylene tube with an inside diameter of 18 mm and a length of 50 mm was filled with each of the above curable compositions and, after 7 days of curing, the cured portion was taken out and the length of the cured portion was measured. The results thus obtained are shown in Table 1.

(Strength Rise)

[0338] Under constant-temperature (23° C.) and constant-humidity (50%) conditions, each of the above curable compositions was applied to an aluminum plate to form a layer with a length of 25 mm, a width of 25 mm and a thickness of 50 μ m, another aluminum plate was placed thereon for sandwiching the layer and, after 24 hours of curing, the sandwich was tested for 180° C. peel strength at a rate of pulling of 200 mm/minute. When the measured value was 1.5 N/mm² or

higher, the peel strength was designated as A and, when it is lower than 1.5 N/mm², as B. The results thus obtained are shown in Table 1.

(Color of Cured Product)

[0339] The curable composition was spread to give a 3-mm-thick sheet-like sample and cured at 23° C. for 3 days and then at 50° C. for 4 days. The cured sample was exposed outdoors for 3 months and the surface color of the cured product was observed by the eye. The results thus obtained are shown in Table 1.

(Adhesiveness)

[0340] Under constant temperature (23° C.) and constant humidity (50%) conditions, each of the above curable compositions, in the form of a rectangle having an approximate size of 30 mm in length, 15 mm in width and 10 mm in thickness, was brought into close contact with an adherend substrate (glass, anodic oxidation aluminum and vinyl chloride resin) and cured for 7 days; then, the adhesiveness was evaluated by 90-degree hand peel test. The adhesiveness evaluation was made in terms of fracture mode. In the case of 80 to 100% cohesive failure, the adhesiveness was evaluated as A; in the case of 40% to below 80% cohesive failure, as B; and in the case of 0% to below 40% cohesive failure, as C. The results thus obtained are shown in Table 1.

TABLE 1

				Examples			Comparative Examples		
				1	2	3	1	2	3
Compo- sition (parts by wt.)	Organic polymer	A-1		100	100		100		
		A-2				100			
		D-1						100	100
	Filler	Hakuenka CCR	Shiraishi Kogyo	120	120	120	120	120	120
		Titanium oxide	Tipaque R-820	20	20	20	20	20	20
		Plasticizer (C)	Actcol P-23	55	55	55	55	55	55
	Thixotropic agent	Disparlon #6500	Kusumoto Chemicals	2	2	2	2	2	2
		Ultraviolet absorber	Tinuvin 327	1	1	1	1	1	1
		Light stabilizer	Sanol LS770	1	1	1	1	1	1
	Adhesiveness- imparting agent	A-1120	Dow Corning Toray	5	3	3	5	5	5
		A-187	Dow Corning Toray	3			3	3	3
		Dehydrating agent	A-171		2	2			
	Guanidine compound (B)	OTBG	Toray Tokyo Chemical Industry	4	4	4	10	4	10
		Surface curability (time required for layer formation)		50 minutes	68 minutes	124 minutes	45 minutes	36 hours	15 hours
		Depth curability		9.2 mm	11.1 mm	10.0 mm	10.3 mm	5.9 mm	5.3 mm

Adhesive-strength rise	A	A	A	A	B	B
Color of cured product	White	White	White	Brown	White	Brown
Adhesiveness (90-degree hand peel)	Glass	A	A	A	A	B
		A	A	A	A	B
		A	A	A	A	B

[0341] As shown in Table 1, when 4 parts by weight of the (B) component OTBG and 55 parts by weight of the (C) component non-phthalate ester type plasticizer were added to 100 parts by weight of the (A) component trimethoxysilyl group-terminated polyoxypropylene type polymer, the surface curability, depth curability, strength rise and adhesiveness were all good and, further, the cured products showed no discoloration even after outdoor exposure (Examples 1 to 3). However, when the addition level of the (B) component OTBG was increased to 10 parts by weight, the cured product, upon outdoor exposure, turned brown (Comparative Example 1).

[0342] On the other hand, when the methyldimethoxysilyl group-terminated polyoxypropylene type polymer (D-1) was used and 4 parts by weight or 10 parts by weight of OTBG was added, the surface curability, depth curability, strength rise and adhesiveness were all inferior to those attained with the trimethoxysilyl group-terminated polyoxypropylene type polymers (Comparative Examples 2 and 3).

Synthesis Example 5

[0343] The allyl-terminated polypropylene oxide (P-2) obtained in Synthesis Example 1 (100 parts by weight) was reacted with 2.1 parts by weight of a 62/38 (mmole ratio) mixture of a silane compound represented by the chemical formula $\text{HSi}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{C}_2\text{H}_4\text{Si}(\text{OCH}_3)_3$ and a silane compound represented by the chemical formula $\text{HSi}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{CH}(\text{CH}_3)\text{Si}(\text{OCH}_3)_3$ in the presence of 150 ppm of an isopropanol solution of platinum-vinylsiloxane complex (platinum content: 3% by weight) as a catalyst at 90° C. for 2 hours to give a dimethyldisiloxane-modified trimethoxysilyl group-terminated polyoxypropylene (A-3). The trimethoxysilyl group-terminated polyoxypropylene type polymer (A-3) thus obtained contained a group (a) represented by the chemical formula $-\text{Si}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{C}_2\text{H}_4\text{Si}(\text{OCH}_3)_3$ and a group (b) represented by the chemical formula $-\text{Si}(\text{CH}_3)_2\text{OSi}(\text{CH}_3)_2\text{CH}(\text{CH}_3)\text{Si}(\text{OCH}_3)_3$ and had an a/b ratio value of 62/38 (mole ratio). As a result of ¹H-NMR measurement (made in CDCl₃ solvent using a Nippon Denshi (JEOL Ltd.) model JNM-LA400), the average number of terminal trimethoxysilyl groups per molecule was found to be about 1.2.

Comparative Example 4

[0344] According to the formulation given in Table 2, 120 parts by weight of surface-treated colloidal calcium carbon-

ate (Hakuenka CCR), 20 parts by weight of titanium oxide (Tipaque R-820), 55 parts by weight of a plasticizer (product of Kyowa Hakko Kogyo, trade name: DIDP), 2 parts by weight of a thixotropic agent (Disparlon #6500), 1 part by weight of an ultraviolet absorber (Tinuvin 327) and 1 part by weight of a light stabilizer (Sanol LS770) were weighed and mixed with 100 parts by weight of the trimethoxysilyl group-terminated polyoxypropylene type polymer (A-3) obtained in Synthesis Example 5 and, after thorough kneading, the mixture was passed through a three-roll paint mill for dispersion. Thereafter, the mixture was dehydrated at 120° C. for 2 hours under reduced pressure and, after cooling to a temperature not higher than 50° C., 3 parts by weight of γ -(2-aminoethyl) aminopropyltrimethoxysilane (A-1120) as an adhesiveness-imparting agent, 2 parts by weight of vinyltrimethoxysilane (A-171) as a dehydrating agent, 3.4 parts by weight of tin versatate (product of Nitto Kasei Co., trade name: Neostann U-50) and 1 part by weight of 3-diethylaminopropylamine (product of Wako Pure Chemical Industries, abbreviated as DEAPA), each as a silanol condensation catalyst, were added and kneaded. After kneading under substantially water-free conditions, the resulting mixture was hermetically packed in a moisture-proof container. A one-pack type curable composition was thus obtained.

Comparative Example 5

[0345] A curable composition was obtained in the same manner as in Comparative Example 4 except that the organic polymer (D-2) was used in lieu of the organic polymer (A-3) used in Comparative Example 4.

Comparative Example 6

[0346] A curable composition was obtained in the same manner as in Comparative Example 4 except that versatic acid (product of Matsumoto Trading., trade name: Versatic 10) was used in an amount of 2.6 parts by weight in lieu of the tin versatate used in Comparative Example 4.

Comparative Example 7

[0347] A curable composition was obtained in the same manner as in Comparative Example 6 except that the organic polymer (D-2) was used in lieu of the organic polymer (A-3) used in Comparative Example 6.

TABLE 2

				Comparative Examples			
				4	5	6	7
Compo- sition (parts by wt.)	Organic polymer	A-3		100		100	
		D-2			100		100
	Filler	Hakuenka CCR	Shiraishi	120	120	120	120
			Kogyo				
	Titanium oxide	Tipaque R-820	Ishihara	20	20	20	20
			Sangyo				
	Plasticizer	DIDP	Kyowa Hakko	55	55	55	55
	Thixotropic agent	Disparlon #6500	Kusumoto	2	2	2	2
			Chemicals				
	Ultraviolet absorber	Tinuvin 327	Ciba Specialty	1	1	1	1
			Chemicals				
	Light stabilizer	Sanol LS770	Sankyo	1	1	1	1

TABLE 2-continued

				Comparative Examples			
				4	5	6	7
Re- sults	Adhesiveness- impacting agent	A-1120	Dow Corning Toray	3	3	3	3
	Dehydrating agent	A-171	Dow Corning Toray	2	2	2	2
	Carboxylic acid tin salt	Neostann U-50	Nitto Kasei	3.4	3.4		
	Carboxylic acid	Versatic 10	Matsumoto Trading			2.6	2.6
	Amine compound	DEAPA	Wako Pure Chemical Industries	1	1	1	1
	Surface curability (time required for layer formation)			92 minutes	125 minutes	109 minutes	115 minutes
	Depth curability			7.3 mm	8.0 mm	7.1 mm	8.3 mm
	Adhesiveness (90-degree hand peel)		Glass	B	B	C	A
			Anodic oxidation aluminum	A	A	C	A
			Vinyl chloride resin FRP	C	C	C	C

[0348] As shown in Table 2, the use of the carboxylic acid metal salt or carboxylic acid as the silanol condensation catalyst caused little differences in surface curability and in depth curability between the trimethoxysilyl group-terminated polyoxypropylene type polymer and methyldimethoxysilyl group-terminated polyoxypropylene type polymer. From the adhesiveness viewpoint as well, the use of the trimethoxysilyl group-terminated polyoxypropylene type polymer showed no superiority (Comparative Examples 4 to 7).

Synthesis Example 6

[0349] To 100 parts by weight of the polypropylene oxide (P-1) obtained in Synthesis Example 1 was added 1.6 parts by weight of γ -isocyanatopropyltrimethoxysilane, and the reaction was allowed to proceed at 90° C. for 5 hours to give a polyoxypropylene type polymer (A-4) containing, on an average, 1.3 terminal trimethoxysilyl groups and containing an amide segment (—NHCO—) at the position γ to each terminal silyl group.

Comparative Example 8

[0350] A curable composition was obtained in the same manner as in Example 1 except that DIDP was used as a plasticizer in lieu of the plasticizer used in Example 1.

Comparative Example 9

[0351] A curable composition was obtained in the same manner as in Example 2 except that DIDP was used as a plasticizer in lieu of the plasticizer used in Example 2.

Comparative Example 10

[0352] A curable composition was obtained in the same manner as in Comparative Example 9 except that the organic polymer (A-4) was used in lieu of the organic polymer (A-1) used in Comparative Example 9, and tin versate (Neostann U-50) in an amount of 3.4 parts by weight and 3-diethylami-

nopropylamine (DEAPA) in an amount of 1 part by weight were used as a silanol condensation catalyst in lieu of the silanol condensation catalyst used in Comparative Example 9.

Comparative Example 11

[0353] A curable composition was obtained in the same manner as in Comparative Example 9 except that the organic polymer (D-1) was used in lieu of the organic polymer (A-1) used in Comparative Example 9, and versatic acid (Versatic 10) in an amount of 2.6 parts by weight and 3-diethylaminopropylamine (DEAPA) in an amount of 1 part by weight were used as a silanol condensation catalyst in lieu of the silanol condensation catalyst used in Comparative Example 9.

Comparative Example 12

[0354] A curable composition was obtained in the same manner as in Comparative Example 11 except that the organic polymer (D-2) was used in lieu of the organic polymer (D-1) used in Comparative Example 11.

Comparative Example 13

[0355] A curable composition was obtained in the same manner as in Comparative Example 9 except that the organic polymer (D-2) was used in lieu of the organic polymer (A-1) used in Comparative Example 9 and diisopropoxytitanium bis(ethylacetoacetate) (product of Matsumoto Fine Chemical, trade name: TC-750) in an amount of 7.5 parts by weight was used as a silanol condensation catalyst in lieu of the silanol condensation catalyst used in Comparative Example 9.

(Percentage of Curing Retardation after Storage)

[0356] Each one-pack type curable composition in a hermetically sealed moisture-proof container was stored at 50° C. for 28 days and then evaluated for surface curability under constant-temperature (23° C.) and constant-humidity (50%) conditions, and the percent change in surface curability as compared with the curability before storage (after storage/before storage) was calculated. The results thus obtained are shown in Table 3.

[0357] The results obtained in Examples 1 to 3 are also shown in Table 3.

TABLE 3

				Examples			Comparative Examples	
				1	2	3	8	9
Compo- sition (parts by wt.)	Organic polymer	A-1		100	100		100	100
		A-2				100		
		A-4						
		D-1						
		D-2						
	Filler	Hakuenka CCR	Shiraishi Kogyo	120	120	120	120	120
	Titanium oxide	Tipaque R-820	Ishihara Sangyo	20	20	20	20	20
	Plasticizer (C)	Actcol P-23	Mitsui Takeda Chemicals	55	55	55		
		DIDP	Kyowa Hakko				55	55
	Thixotropic agent	Disparion #6500	Kusumoto Chemicals	2	2	2	2	2
	Ultraviolet absorber	Tinuvin 327	Ciba Specialty Chemicals	1	1	1	1	1
	Light stabilizer	Sanol LS770	Sankyo	1	1	1	1	1
	Adhesiveness- impacting agent	A-1120	Dow Corning	5	3	3	5	3
		A-187	Toray Dow Corning Toray	3			3	
	Dehydrating agent	A-171	Dow Corning Toray		2	2		2
	Guanidine compound (B)	OTBG	Tokyo Chemical Industry	4	4	4	4	4
	Carboxylic acid tin salt	Neostann U-50	Nitto Kasei					
	Carboxylic acid	Versatic 10	Matsumoto Trading					
	Amine compound	DEAPA	Wako Pure Chemical Industries					
	Titanium compound	TC-750	Matsumoto Fine Chemical					
Re- sults	Surface curability (time required for layer formation)			50 minutes	68 minutes	124 minutes	48 minutes	45 minutes
	Surface curability (after storage)			40 minutes	55 minutes	123 minutes	165 minutes	120 minutes
	Percentage of curing retardation after storage			80%	81%	99%	344%	267%
	Adhesiveness (90-degree hand peel)			A	A	A	A	A
			Anodic oxidation aluminum					
			Steel plate	A	A	A	A	A
			Vinyl chloride	A	A	A	A	A
			steel plate FRP	A	A	A	A	A
				Comparative Examples				
				10	11	12	13	
Compo- sition (parts by wt.)	Organic polymer	A-1						
		A-2						
		A-4		100				
		D-1			100			
		D-2				100	100	
	Filler	Hakuenka CCR	Shiraishi Kogyo	120	120	120	120	
	Titanium oxide	Tipaque R-820	Ishihara Sangyo	20	20	20	20	
	Plasticizer (C)	Actcol P-23	Mitsui Takeda Chemicals					
		DIDP	Kyowa Hakko	55	55	55	55	
	Thixotropic agent	Disparion #6500	Kusumoto Chemicals	2	2	2	2	
	Ultraviolet	Tinuvin 327	Ciba Specialty	1	1	1	1	

TABLE 3-continued

	absorber		Chemicals				
	Light stabilizer	Sanol LS770	Sankyo	1	1	1	1
	Adhesiveness-imparting agent	A-1120	Dow Corning	3	3	3	3
		A-187	Toray				
			Dow Corning				
	Dehydrating agent	A-171	Toray	2	2	2	2
	Guanidine compound (B)	OTBG	Toray				
	Carboxylic acid tin salt	Neostann U-50	Tokyo Chemical Industry	3.4			
	Carboxylic acid	Versatic 10	Matsumoto Trading		2.6	2.6	
	Amine compound	DEAPA	Wako Pure Chemical Industries	1	1	1	
	Titanium compound	TC-750	Matsumoto Fine Chemical				7.5
Re-	Surface curability (time required for layer formation)			37 minutes	90 minutes	115 minutes	110 minutes
sults	Surface curability (after storage)			42 minutes	142 minutes	190 minutes	107 minutes
	Percentage of curing retardation after storage			114%	158%	165%	97%
	Adhesiveness (90-degree hand peel)		Anodic oxidation aluminum	A	A	A	A
			Steel plate	C	C	C	B
			Vinyl chloride steel plate	B	C	C	C
			FRP	B	A	C	A

[0358] As shown in Table 3, the curability was retained after storage when the non-phthalate ester type plasticizer (Actocol P-23) accounting for 100% by weight of the component (C) was added to the trimethoxysilyl group-terminated polyoxypropylene type polymer (A) and OTBG (B) (Examples 1 to 3).

[0359] On the other hand, when the phthalate ester type plasticizer (DIDP) accounting for 100% by weight of the component (C) was added, the decrease in curability after storage was large (Comparative Examples 8 and 9).

[0360] On the contrary, the use of the carboxylic acid tin salt, carboxylic acid and titanium compound as the silanol condensation catalyst, even when the phthalate ester type plasticizer (DIDP) accounting for 100% by weight of the component (C) was added, gave inferior adhesiveness as compared with OTBG (B), although the decrease in curability after storage was small (Comparative Examples 10 to 13).

1. A non-organotin curable composition which comprises:

(A) an organic polymer containing a silyl group capable of crosslinking under siloxane bond formation, said silyl group being a group represented by the general formula (1):



(wherein X represents a hydroxyl group or a hydrolyzable group and the three X groups may be mutually the same or different),

(B) a guanidine compound (B-1) as a silanol condensation catalyst, and

(C) a plasticizer,

wherein the content of the component (B-1) is not lower than 0.1 part by weight but lower than 8 parts by weight per 100 parts by weight of the component (A),

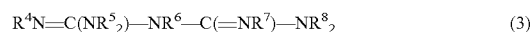
and a non-phthalate ester plasticizer accounts for 80 to 100% by weight of the (C) component plasticizer.

2. The curable composition according to claim 1, wherein the component (B-1) is a guanidine compound represented by the general formula (2):

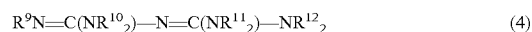


(wherein R^1 , the two R^2 's and the two R^3 's are independently an organic group or a hydrogen atom, provided that four or more of R^1 , the two R^2 's and the two R^3 's are independently an organic group other than an aryl group, or a hydrogen atom).

3. The curable composition according to claim 2, wherein the component (B-1) represented by the general formula (2) is a biguanide compound represented by the general formula (3):



(wherein R^4 , the two R^5 's, R^6 , R^7 and the two R^8 's are independently an organic group or a hydrogen atom, and/or the general formula (4):



(wherein R^9 , the two R^{10} 's, the two R^{11} 's and the two R^{12} 's are independently an organic group or a hydrogen atom).

4. The curable composition according to claim 1, wherein the component (B-1) is a guanidine compound having a melting point of not lower than 23° C.

5. The curable composition according to claim 1, wherein a main chain skeleton of the (A) component organic polymer contains at least one atom selected from among a hydrogen atom, a carbon atom, a nitrogen atom, an oxygen atom and a sulfur atom.

6. The curable composition according to claim 1, wherein the (A) component organic polymer comprises at least one species selected from the group consisting of polyoxyalkylene polymers, saturated hydrocarbon polymers and (meth)acrylate ester polymers.
7. The curable composition according to claim 6, wherein the polyoxyalkylene polymer is a polyoxypropylene polymer.
8. The curable composition according to claim 1, wherein a main chain skeleton of the (A) component organic polymer contains a group represented by the general formula (5):



(wherein R¹³ is an organic group or a hydrogen atom).

9. The curable composition according to claim 1, which contains the (C) component plasticizer in an amount of 5 to 150 parts by weight per 100 parts by weight of the (A) component organic polymer.
10. A one-pack curable composition which comprises the curable composition according to claim 1.
11. A sealant which comprises the curable composition according to claim 1.
12. An adhesive which comprises the curable composition according to claim 1.

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