

SPECIFICATION

Title of Invention

CURABLE COMPOSITION

Technical Field

[0001]

The present invention relates to a curable composition which essentially contains a combination of a polyorganosiloxane compound having a viscosity falling within a specific range, a catalyst consisting of a specific metal compound, and a volatile organic compound having a boiling point falling within a specific range, at a specific compositional ratio, and relates to a curable composition which can harden under a room-temperature environment to form a coating imparting water repellency, water sliding property and durability to a metal surface, a painted surface or a resin surface, particularly preferably a painted surface such as an automobile body.

Background Art

[0002]

Solid, semi-solid or liquid curable compositions have conventionally been applied and laid on a painted steel sheet of an automobile body and the like for the purpose of protection and aesthetic improvement. As such a curable composition, a composition obtained by adding a volatile organopolysiloxane oil and a volatile dimethylpolysiloxane to a moisture-curable organopolysiloxane, an organic solvent and a curing catalyst (Patent Document 1); and a composition to which a high-viscosity silicone gum is added (Patent Document 2) are known, for example. However, these

compositions were difficult to exhibit water repellency for a long time, because the non-reactive organopolysiloxane oil volatilized and dissipated over time.

[0003]

In order to solve the above-mentioned problem, various compositions consisting of a moisture-curable silicone oligomer, an organic solvent, a curing catalyst, and a silicone oil having a reactive functional group in the molecule have been proposed. Patent Document 3 discloses a composition using a reactive silicone oil having a reactive group selected from a carbinol group, a carboxy group, an amino group, a hydroxyl group (a silanol group) and the like at both terminals of the molecular chain, and Patent Document 4, Patent Document 5, etc. disclose compositions obtained by diluting a low-viscosity reactive silicone oligomer having an alkoxysilyl group at the terminal of the molecular chain in an alcohol-based solvent, a paraffin-based solvent, an aromatic solvent, an ester-based solvent, a glycol-based solvent, or the like. Furthermore, Patent Document 6 proposes a composition using a reactive silicone oil having a carbinol group or an amino group at the side chain of the molecule, and Patent Document 7 proposes a composition comprising a fluorine-containing alkoxysilane. Patent Document 8, Patent Document 9, Patent Document 10, Patent Document 11, etc. disclose compositions obtained by diluting a reactive silicone oligomer having an alkoxysilyl group at the terminal of the molecular chain with a large amount of solvent such as isoparaffin-based solvent and kerosene. Patent Document 12 discloses a composition obtained by diluting a reactive silicone oligomer with a high-boiling point isoparaffin-based solvent.

Prior Art Documents

Patent Documents

[0004]

Patent Document 1: Japanese Patent Application Laid-Open No. 10-36771

Patent Document 2: Japanese Patent Application Laid-Open No. 2013-194058

Patent Document 3: Japanese Patent Application Laid-Open No. 2008-75021

Patent Document 4: Japanese Patent Application Laid-Open No. 2006-45507

Patent Document 5: Japanese Patent Application Laid-Open No. 2007-161989

Patent Document 6: Japanese Patent Application Laid-Open No. 2010-31074

Patent Document 7: WO 1996/000758, pamphlet

Patent Document 8: Japanese Patent Application Laid-Open No. 2009-138063

Patent Document 9: Japanese Patent Application Laid-Open No. 2009-138062

Patent Document 10: Japanese Patent Application Laid-Open No. 2013-166957

Patent Document 11 Japanese Patent Application Laid-Open No. 2010-202717

Patent Document 12: Japanese Patent Application Laid-Open No. 2012-241093

Summary of Invention

Problem to be solved

[0005]

However, all of these compositions are difficult to simultaneously satisfy properties such as storage stability in an uncured state, water repellency of a cured film, water slip property (water sliding property) and wear resistance. Furthermore, wet-wiping or another agent wiping up is required for evenly applying these compositions. If trying to lay the compositions by only dry-wiping, it cannot be wiped off smoothly, resulting in an uneven film, and thereby homogenous film formation is difficult. That is, these compositions have poor workability.

Solution to Problem

[0006]

Thus, it was difficult to satisfy the properties required for the coating and the like with the conventional coating-forming curable composition. As a result of intensive studies to improve these properties, the present invention is to use a curable

composition having the following constitution: (A) 100 parts by mass of a silicone resin having a viscosity of $50\text{-}500\text{ mm}^2\text{s}^{-1}$ at 25°C and having a hydrolysable reactive group, (B) 1.0-30 parts by mass of an aluminum-based catalyst for condensation reaction, and (C) 600-1700 parts by mass of an organic solvent which contains 40 mass% or more of a naphthene hydrocarbon compound and of which the boiling point or the temperature range from the initial boiling point to the dry point falls within a range of $140\text{-}200^\circ\text{C}$.

[0007]

Also, the present invention includes the following embodiments. The second embodiment is the curable composition according to the first embodiment, for which the boiling point or the temperature range from the initial boiling point to the dry point of the (C) falls within a range of $142\text{-}175^\circ\text{C}$, and a temperature difference between the initial boiling point and the dry point (temperature distribution) is within 20°C when the boiling points are not one temperature.

[0008]

The third embodiment is the curable composition according to the first or second embodiment which forms a coating on a surface of a steel plate or a painted steel plate.

[0009]

The fourth embodiment is the curable composition according to the third embodiment for which the steel plate or the painted steel plate is an automobile body.

[0010]

The fifth embodiment is a method for forming a coating by: applying the curable composition according to any one of the first to fourth embodiments on the surface of the automobile body; volatilizing the (C) under a normal-temperature or heating environment; and then dry-wiping, or wet-wiping followed by dry-wiping, the surface.

[0011]

The sixth embodiment is a cured coating formed by the method for forming the

coating according to the fifth embodiment.

Effects of Invention

[0012]

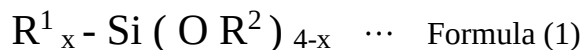
The curable composition according to the present invention is used, so that it becomes possible to provide a coating, on steel plates or painted steel plates used for automobile bodies and the like, which has a preferable water repellency and water sliding property and is excellent in wear resistance, storage stability, workability in a wiping step, and the like.

Description of Embodiments

[0013]

Hereinafter, the details of the present invention will be explained. Component (A) contained in the curable composition according to the present invention is a silicone resin having a viscosity of $50\text{-}500\text{ mm}^2\text{s}^{-1}$ at 25°C and having a hydrolyzable reactive group in its molecule. The component exerts a main action in expressing functions such as water repellency, water sliding property and wear resistance in the cured coating made of the curable composition according to the present invention. Herein, the silicone resin refers to a compound obtained by subjecting a polyfunctional alkoxy silane compound to partial hydrolysis and dealcoholization condensation (also referred to as partial hydrolysis condensation herein) with a known catalyst such as an acid, a base, an organotin compound or an organotitanium compound, and also refers to a silicone compound having a hydrolyzable group derived from the alkoxy silane compound at the molecular chain terminal and/or side chain and the like, and having a linear or three-dimensional network structure. Typically, the compound is a partially hydrolyzed condensate of an alkoxy silane compound represented by the following structural formula (1).

[0014]



Herein, each of R^1 and R^2 independently represents an aliphatic, alicyclic or aromatic hydrocarbon group having 1-8 carbon atoms which may have a substituent, preferably an aliphatic hydrocarbon group having 1-5 carbon atoms, and particularly preferably a substituent selected from a methyl group, an ethyl group and a propyl group. In addition, x represents an integer of 0-3, preferably 0 or 1, particularly preferably 1. The component (A) can be prepared by: adding a known hydrolysis catalyst to the compound represented by the above-mentioned structural formula; and stirring the mixture while heated in the presence of moisture so as to cause the partial hydrolysis condensation. In the above-mentioned structural formula, when x represents 0 or 1, the polymer of the compound will have an alkoxy group represented by (OR^2) at the side chain when the polymer is linear, or alternatively the polymer does not have a linear structure but constitutes a three-dimensional crosslinked body, and partly contains an alkoxy group in the structure. Although x may be 2 or 3 for the compound, a compound in which x represents 0 or 1 is preferable for effectively adding an alkoxy group to the structure of the component (A).

[0015]

In the component (A), a measurement value of a viscosity of the compound alone at 25°C in accordance with JIS-Z-8803 falls within a range of 50-500 mm²s⁻¹. In the present invention, the viscosity of the component (A) falls within the above-mentioned range, so that the cured coating of the curable composition can possess good water repellency, water sliding property or wear resistance, or a plurality of these properties.

[0016]

As the component (A), any commercial product can be appropriately used as

long as it has the above-mentioned properties. It can be exemplified by X-40-9250 (available from Shin-Etsu Chemical Co., Ltd., a partially hydrolyzed condensate of a mixture in which both R^1 and R^2 represent methyl groups and $x = 1$ and 2 in the formula (1), a viscosity at 25°C is about $160\text{ mm}^2\text{s}^{-1}$), X-40-9225 (available from Shin-Etsu Chemical Co., Ltd., a compound in which both R^1 and R^2 represent methyl groups in the formula (1), a weight-average molecular weight is about $3,600$, a viscosity at 25°C is $100\text{ mm}^2\text{s}^{-1}$), X-40-9246 (available from Shin-Etsu Chemical Co., Ltd., a compound in which both R^1 and R^2 represent methyl groups in the formula (1), a weight-average molecular weight is about $6,000$, a viscosity at 25°C is $80\text{ mm}^2\text{s}^{-1}$), XR31-B 2733 (available from Momentive Performance Materials Japan LLC, a partially hydrolyzed condensate of a mixture in which R^1 represents a methyl group and a phenyl group, R^2 represents a methyl group, and $x = 1$ and 2 in the formula (1), a viscosity at 25°C is about $220\text{ mm}^2\text{s}^{-1}$), SH 550 (available from Dow Corning Toray Co., Ltd., a partially hydrolyzed condensate in which R^1 represents a methyl group and a phenyl group, R^2 represents a methyl group, and $x = 2$ in the formula (1), a viscosity at 25°C is about $135\text{ mm}^2\text{s}^{-1}$), and the like, and they may be used alone or in combination.

[0017]

The component (B) contained in the curable composition according to the present invention is an aluminum-based catalyst for condensation reaction, which is a compound for condensation reaction by reaction of the hydrolyzable group (Si-OR^2) contained in component (A) with air moisture and the like. In the present invention, an aluminum-based compound is used as a catalyst for condensation reaction, so that degradation of the appearance due to coloring of the cured coating or the like can be prevented. As the aluminum-based catalysts for condensation reaction, various organoaluminum compounds are known, which can be exemplified by an aluminum salt compound such as aluminum octylate, aluminum triacetate and aluminum tristearate; an

aluminum alkoxide compound such as aluminum trimethoxide, aluminum triethoxide, aluminum triallyloxy and aluminum triphenoxide; an aluminum chelate compound such as aluminum methoxy bis(ethylacetoacetate), aluminum methoxy bis(acetylacetonate), aluminum ethoxy bis(ethylacetoacetate), aluminum ethoxy bis(acetylacetonate), aluminum isopropoxy bis(ethylacetoacetate), aluminum isopropoxy bis(methyl acetoacetate), aluminum isopropoxy bis(t-butylacetoacetate), aluminum butoxy bis(ethylacetoacetate), aluminum dimethoxy (ethylacetoacetate), aluminum dimethoxy (acetylacetonate), aluminum diethoxy (ethylacetoacetate), aluminum diethoxy (acetylacetonate), aluminum diisopropoxy (ethylacetoacetate), aluminum diisopropoxy (methylacetoacetate), aluminum tris(ethylacetoacetate), aluminum tris(acetylacetonate) and aluminum octylacetoacetate diisopropylate, and the like, and they may be used alone or in combination. Above all, aluminum tris(acetylacetonate), aluminum tris(ethylacetoacetate), aluminum diisopropoxy (ethylacetoacetate), aluminum octylacetoacetate diisopropylate, aluminum monoacetylacetonate bis(ethylacetoacetate) are particularly preferable.

[0018]

As the component (B), known commercial products can be used, e.g., DX-9740 (mixture of aluminum alkoxide compounds) and CAT-AC (mixture of aluminum alkoxide compounds, a diluted product of 50 mass% toluene) available from Shin-Etsu Chemical Co., Ltd., as well as Alumichelate A (W) (aluminum tris(acetylacetonate)), Alumichelate D (aluminum monoacetylacetonate bis(ethylacetoacetate), active ingredient: 76 mass%), AIPD (aluminum isopropylate), ALCH (aluminum diisopropoxy (ethylacetoacetate)) and ALCH-TR (aluminum tris(ethyl acetoacetate)) available from Kawaken Fine Chemicals Co.,Ltd., and the like are used, and they may be used alone or in combination.

[0019]

The composition amount of the component (B) in the present invention falls within a range of 1.0-30 parts by mass, preferably 1.5-25 parts by mass based on 100 parts by mass of the component (A). If the amount is less than the above-mentioned composition amount, there is a possibility that the curable composition according to the present invention cannot form a cured coating having a sufficient strength due to poor curing, and on the other hand, if the amount exceeds the above-mentioned composition amount, there is a possibility that the curable composition according to the present invention has a problem of storage stability at normal temperature.

[0020]

The component (C) contained in the curable composition according to the present invention is an organic solvent which contains 40 mass% or more of a naphthene hydrocarbon compound and of which the boiling point falls within a range of 140-200°C, preferably 141-185°C, particularly preferably 142-175°C, which is an essential component in a process that the component (A) and the component (B) are uniformly dissolved and diluted to form a thin film. The naphthene hydrocarbon compound described in the present invention refers to a saturated hydrocarbon having a cyclic structure in the molecule, and as long as the compound has this structure, the cyclic structure may include one or more functional groups such as a halogen group or various organic groups. From the viewpoints of reactivity, odor, viscosity, etc. of the composition, it is particularly preferable that the functional group is a hydrocarbon group having at least about 3 carbon atoms such as a methyl group, an ethyl group, an n-propyl group and an i-propyl group. When the boiling point of the component (C) is not lower than the lower limit value of the above-mentioned range, the curable composition according to the present invention can stay in a liquid state on the substrate in a period necessary for forming a film. On the other hand, when the boiling point is

not more than the upper limit value of the above-mentioned range, the curable composition according to the present invention can have appropriate volatility and obtain preferable workability. Herein, when the boiling points are not one temperature because of the component being a mixture or the like, the boiling point range in the present invention refers to a range including the boiling starting temperature (initial boiling point) and the boiling end temperature (dry point). In this case, from the viewpoint of workability, it is particularly preferable that the temperature difference (temperature distribution) between the initial boiling point and the dry point is within 20°C.

[0021]

An organic solvent containing 40 mass% or more of a naphthene hydrocarbon compound as the component (C) is used, so that the cured product of the component (A) which has been progressively cured on the substrate can be homogeneously spread by dry-wiping when forming the cured coating of the curable composition according to the present invention. Although the specific mechanism for expressing such a function is unknown, it is considered that, by using an organic solvent having the above-mentioned constitution, the solvent can act like a plasticizer in the cured product which has been progressively cured on the substrate to soften the cured product to some extent, enabling to stretch the cured product by the external force of dry-wiping, so that the cured product can be formed into a thin film on the substrate.

[0022]

In the present invention, as a naphthene hydrocarbon compound contained in the organic solvent, any material can be appropriately selected. Herein, when the organic solvent is a material consisting only of a naphthene hydrocarbon compound, the solvent can be exemplified by propylcyclohexane (boiling point: 155°C), 1,3,5-trimethylcyclohexane (boiling point: 140°C), 1,2,3-trimethylcyclohexane (boiling point:

151°C), 1,2,4-trimethylcyclohexane (boiling point: 145°C), cyclooctane (boiling point: 149°C), 1,1,3,5-tetramethylcyclohexane (boiling point: 148°C), cyclooctane (boiling point: 149°C), and the like. Each of these naphthene hydrocarbon compounds may be used alone or as a mixture of plural kinds. If the temperature range from the boiling point, i.e., initial boiling point, to the dry point of the mixture is included within the above-mentioned temperature range, the mixture may contain a naphthene hydrocarbon compound in which the boiling point of the compound alone falls outside the above-mentioned range. Additionally, in the present invention, if the boiling point of the whole organic solvent is within the above-mentioned range, the organic solvent may contain an organic solvent compound other than the naphthene hydrocarbon compound. In this case, a ratio of the naphthene hydrocarbon compound to the whole organic solvent is 30 mass% or more.

[0023]

As a commercial product of the organic solvent, a product sold as a mixture of various naphthene hydrocarbon compounds can be used, and exemplified by Swaclean 150 (initial boiling point: 145°C, dry point: 170°C) and Naphtesol 160 (initial boiling point: 157°C, dry point: 179°C) available from Maruzen Petrochemical CO,LTD., Exxsol D 30 (initial boiling point: 145°C, dry point: 163°C) and Exxsol D40 (initial boiling point: 166°C, dry point: 191°C) available from Exxon Mobil Corporation, and the like.

[0024]

The composition amount of the component (C) in the present invention falls within a range of 600-1700 parts by mass, preferably 700-1600 parts by mass based on 100 parts by mass of the component (A). When the composition amount falls within this range, the curable composition according to the present invention can acquire both adequate volatility and coating formability, and can be laid with a good workability so

as to achieve homogenous coating formation.

[0025]

Furthermore, in the curable composition according to the present invention, any additives can be appropriately added unless the properties are damaged. Components corresponding to a purpose, e.g., an adhesion imparting agent such as reactive or non-reactive silicone oil, alkoxysilane compound and silane coupling agent, an antioxidant, a corrosion inhibitor, a colorant, a surfactant, a rheology modifier, an ultraviolet absorber, an infrared absorber, a fluorescence agent, an abrasive, a perfume, a filler and the like can be selected.

[0026]

The curable composition according to the present invention can be applied to substrates such as various metals, glass, ceramics and resin, preferably to a metal steel plate, a painted metal steel plate or a glass surface, particularly preferably to a painted steel plate used for automobile exterior (also referred to as an automobile exterior steel plate in this specification).

[0027]

Also, the present invention relates to a method for forming a coating using the curable composition. The method for forming a coating according to the present invention comprises: applying the curable composition on the surface of the automobile body; volatilizing the (C) under a normal-temperature or heating environment; and then dry-wiping, or wet-wiping followed by dry-wiping, the surface. Although the latter applying method, i.e., the dry-wiping after the wet-wiping may be adopted, the present invention is characterized in that a cured coating having good properties can be obtained from the curable composition according to the present invention even by only dry-wiping, and thereby the workability during applying is excellent.

[0028]

The application means in forming the coating of the curable composition is not particularly limited, and any application means, e.g., manual application using a fiber impregnated with the composition, brush application, mechanical application using an automatic machine, and the like can be appropriately selected. In the present invention, application in accordance with the following method is particularly preferable. That is, the method comprises: impregnating a fiber such as a dry sponge or waste cloth with a suitable amount of the curable composition according to the present invention; thinly spreading the curable composition onto the surface of the substrate by hand; and volatilizing volatile components by natural drying or forced drying using a dryer or the like. At this time, the component (A) which is the reactive component contained in the composition contacts the moisture in the air to advance the hydrolysis reaction by the action of the catalyst (B), and is cross-linked and cured on the substrate in parallel with volatilization of the volatile component to form a resinous cured product. Thereafter, the cured product can be spread out by dry-wiping with a dry cloth or the like to form a coating layer with a homogeneous cured coating. For the conventionally known curable composition, wet-wiping after volatilization of the volatile components, or a post-process in which the surface is treated with a treatment liquid for another wiping up, and then dry-wiped with a dry cloth, have been required during the applying. On the other hand, although the curable composition according to the present invention may be subjected to these post-processes, a homogeneous cured coating can be obtained even by only dry-wiping with the dry cloth after volatilization of the solvent, which is extremely excellent in workability. Herein, the cured coating made of the curable composition according to the present invention is preferably a thin film, and preferably has a film thickness of approximately 0.002-75 μm , preferably 0.01-50 μm , more preferably 0.05-10 μm . When the film thickness of the cured coating falls within the above-mentioned range, good water repellency, water sliding property, workability

during applying and wear resistance can be concurrently achieved.

[0029]

Hereinafter, the effects of the present invention will be explained in detail with reference to Examples, but these Examples are not intended to limit the embodiments of the present invention.

Examples

[0030]

The properties of the curable composition according to the present invention were evaluated in the following Examples and Comparative Examples. Herein, in relation to the respective properties, a composition of which not more than one property was rated as "Medium (triangle Δ)" is preferable, and a composition of which all properties were rated as "Good (circle $\bigcirc$)" is more preferable, as the composition to be used for the purpose of coating formation. In addition, each curable composition (hereinafter, also referred to simply as "composition") evaluated in Examples and Comparative Examples according to the present invention was prepared by mixing raw materials shown in Tables 1 and 2 with a mass ratio described in the same tables, and stirring at 25°C for 30 minutes.

[0031]

[Method for evaluating water repellency/water sliding property]

About 2 ml of each composition shown in the tables was infiltrated into tissue paper, thinly applied on a black painted plate (available from ASAHI-BETECHNO K.K., material: SPCC-SD, standard: JIS-G-3141, size: 0.8 mm×70 mm×150 mm, one surface was painted black with aminoalkyd after chemical conversion and electrodeposition) by hand, allowed to stand in a room at 25°C for 10 minutes, and then a remainder was wiped off with a dry microfiber cloth. This was further allowed to stand in a room at 25°C for 2 weeks for curing, to obtain a test piece coated with each

composition. One drop (about 0.05 ml) of purified water was dropped to this test piece, and a contact angle with the water drop (water contact angle) was measured using a contact angle meter (DM-500, available from Kyowa Interface Science Co., Ltd.) to evaluate the water repellency. The water repellency was evaluated in accordance with an evaluation criterion, where a test piece having a water contact angle of larger than 95° was rated as "Good (○)", a test piece having a water contact angle of $83-95^{\circ}$ was rated as "Medium (Δ)", and a test piece having a water contact angle of smaller than 83° was rated as "Bad (cross ×)". In addition, one drop (about 0.05 ml) of purified water was dropped to the same test piece, the test piece was gradually inclined from a horizontal state, and an angle at which the water droplet started to flow (water sliding angle) was visually observed to evaluate the water sliding property. The water sliding property was evaluated in accordance with an evaluation criterion, where a test piece having a water sliding angle of smaller than 35° was rated as "Good (○)", a test piece having a water sliding angle of $35-45^{\circ}$ was rated as "Medium (Δ)", and a test piece having a water sliding angle of larger than 45° was rated as "Bad (×)".

[0032]

[Method for evaluating wear resistance]

A test piece on which the composition was applied was prepared by the same method as used for evaluating the water repellency/water sliding property. The surface on a side of the test piece on which the composition was applied was subjected to a wear resistance test using a simple friction tester (available from Imoto Machinery Co., Ltd.). In the test, a moving plate on which the test piece was fixed was reciprocated with one round-trip of 100 mm at a rate of 30 times a minute, and on the center of the test piece, a frictional object loaded with a 300 g weight was placed, which object was reciprocated 300 times to abrade the test piece. A water contact angle of the surface after wear was measured in the same manner as described above to evaluate the wear

resistance. Evaluation was carried out in accordance with an evaluation criterion, where a test piece of which a water contact angle after 300 reciprocations was larger than 90% of the water contact angle before wear was rated as "Good (○)", a test piece of 75-90% was rated as "Medium (Δ)", and a test piece of smaller than 75% was rated as "Bad (×)". Herein, the frictional object used in the test was prepared by wrapping a dried clean fabric having a width of 40 mm impregnated with an adequate amount of distilled water (water-absorbable cloth made of cellulose/cotton composite fiber, "Threebond 6644E" available from ThreeBond Co., Ltd.) around a stainless steel cylinder having a diameter of 20 mm, and placed so that the axis of the cylinder was oriented in a direction orthogonal to the moving direction of the moving plate.

[0033]

[Method for evaluating workability]

The composition was applied on the coated plate under the same conditions as in the evaluation of the water repellency and water sliding property, which was allowed to stand in a room at 25°C for 10 minutes, then the remainder was dry-wiped with a dry microfiber cloth, and the workability was evaluated by a sensory test on the resistance during wiping. Evaluation was carried out in accordance with an evaluation criterion, where a test piece which could be wiped evenly with light force was rated as "Good (○)", and a test piece on which jaggedness was felt during wiping was rated as "Bad (×)".

[0034]

[Method for evaluating storage stability]

About 50 g of each composition shown in the tables was put into a 100 ml colorless transparent glass bottle, sealed, stored in a thermostat bath set to 40°C for 1 month, and then an appearance of the liquid was visually observed to evaluate the storage stability. Evaluation was carried out in accordance with an evaluation criterion,

where a test piece showing no discoloration was rated as "Good (○)", a test piece showing slight yellowing or browning was rated as "Medium (Δ)", and a test piece showing apparent discoloration was rated as "Bad (×)".

[0035]

The following materials were used as raw materials contained in each composition of Examples and Comparative Examples.

(A) Silicone resins having a viscosity of 50-500 mm²s⁻¹ at 25°C and having a hydrolysable reactive group, and a comparative component therefor:

· X-40-9250: a compound available from Shin-Etsu Chemical Co., Ltd., in which both R¹ and R² represent methyl groups in the formula (1), a weight-average molecular weight is about 2,100 and a viscosity at 25°C is 160 mm²s⁻¹;

· X-40-9225: a compound available from Shin-Etsu Chemical Co., Ltd., in which both R¹ and R² represent methyl groups in the formula (1), a weight-average molecular weight is about 3,600 and a viscosity at 25°C is 100 mm²s⁻¹;

· X-40-9246: a compound available from Shin-Etsu Chemical Co., Ltd., in which both R¹ and R² represent methyl groups in the formula (1), a weight-average molecular weight is about 6,000 and a viscosity at 25°C is 80 mm²s⁻¹;

· (Comparative product) KR-500: a compound available from Shin-Etsu Chemical Co., Ltd., in which both R¹ and R² represent methyl groups in the formula (1), a weight-average molecular weight is about 1,000 and a viscosity at 25°C is 25 mm²s⁻¹.

(B) An aluminum-based catalyst for condensation reaction, and comparative components therefor:

· DX 9740: an aluminum alkoxide compound available from Shin-Etsu Chemical Co., Ltd.;

· (Comparative product) D25: an organotitanium-based catalyst available from Shin-Etsu Chemical Co., Ltd.;

- (Comparative product) ORGATIX TC401: a 2-propanol solution containing 65 mass% of titanium tetraacetylacetonate, available from Matsumoto Fine Chemical Co.Ltd..

(C) Organic solvents having a boiling point within a range of 140-200°C and containing a naphthene hydrocarbon compound, and comparative components therefor:

- Swaclean 150: an organic solvent comprising a mixture of a C₉ alkylcyclohexane, available from Maruzen Petrochemical CO., LTD., the initial boiling point is 145°C and the dry point is 170°C;

- Exxsol D30: an organic solvent containing about 50% of a dearomatized naphthene hydrocarbon compound, available from Exxon Mobil Corporation, the initial boiling point is 145°C and the dry point is 163°C;

- Exxsol D40: an organic solvent containing about 90% of a dearomatized naphthene hydrocarbon compound, available from Exxon Mobil Corporation, the initial boiling point is 166°C and the dry point is 191°C;

- (Comparative product) Exxsol D80: an organic solvent comprising a hydrogenated light naphtha hydrocarbon compound, available from Exxon Mobil Corporation, the initial boiling point is 205°C and the dry point is 240°C;

- (Comparative product) KYOWASOL C-900: an organic solvent comprising a mixture of a C₉ alkane isomer, available from KH Neochem Co., Ltd., the initial boiling point is 131°C and the dry point is 141°C.

[0036]

[Table 1]

	Raw Material	Ex. 1	Ex. 2	Ex. 3	Ex. 4	Ex. 5	Ex. 6	Ex. 7
(A)	X-40-9250	1.0	1.0	1.0	1.0	1.0	1.0	1.0
(B)	DX 9740	0.11	0.13	0.17	0.14	0.13	0.17	0.11
(C)	Swaclean 150					14.7	13.3	
	D30	13.3	13.3	13.3	14.3			
	D40							13.3
Evaluation of Property	Water Repellency	○	○	○	○	○	○	○
	Water Sliding Property	○	○	○	○	○	○	○
	Wear Resistance	○	○	○	○	○	○	Δ
	Workability	○	○	○	○	○	○	○
	Storage Stability	○	○	○	○	○	○	○

[Table 2]

	Raw Material	Comp. Ex. 1	Comp. Ex. 2	Comp. Ex. 3	Comp. Ex. 4	Comp. Ex. 5	Comp. Ex. 6	Comp. Ex. 7	Comp. Ex. 8
(A)	X-40-9250	1.0	1.0	1.0	1.0	1.0			
	X-40-9225							1.0	
	X-40-9246								1.0
(A)'	KR500								
(B)	DX 9740			0.17			1.0		
(B)'	D 25	0.05	0.13				0.05		0.11
	TC401				0.012	0.013			
(C)	Swaclean 150								
	D30	12.5			16.7	14.3	12.5	18.0	20.0
	D80		13.3						
(C)'	C900			13.3					
Evaluation of Property	Water Repellency	○	×	○	○	○	×	×	Δ
	Water Sliding Property	○	×	○	○	○	Δ	×	Δ
	Wear Resistance	○	○	○	Δ	Δ	Δ	×	×
	Workability	○	○	×	○	○	×	×	○
	Storage Stability	×	×	○	Δ	Δ	×	×	○

[0038]

In Examples of Table 1, it could be confirmed that all of the compositions according to the present invention containing respective constituents (A) to (C) at a predetermined compositional ratio were excellent in water repellency, water sliding property, wear resistance, workability and storage stability. In Example 7, since the volatilization of (C) during applying was somewhat retarded because of using a material having a slightly higher boiling point range as (C), it was considered that a somewhat larger quantity of composition was wiped off and removed during wiping, thus the thickness of the coating was decreased, and as a result, the wear resistance was slightly poor. On the other hand, according to Comparative Examples of Table 2, it was confirmed that Comparative Examples 1, 4 and 5 using materials as (B) other than the materials according to the present invention, for example, had the insufficient storage stability. Comparative Example 2 using materials as (B) and (C) other than the materials according to the present invention is poor at not only the storage stability but also the water repellency and the water sliding property. Comparative Example 3 using a material as (C) having a boiling point out of the range according to the present invention has the unpreferable workability. Comparative Example 6 using materials as (A) and (B) other than the materials according to the present invention were not good at all of the properties. For Comparative Examples 7 and 8 in which the composition of (A), (B) and (C) was at a mass ratio out of the specific range according to the present invention, it was confirmed that a sufficient film thickness could not be formed because of low concentration of the composition, both Comparative Examples showed poor wear resistance, and properties such as water repellency and water sliding property were also insufficient. As described above, it was confirmed that, unless the composition contained all the predetermined constituents according to the present invention, any one or more of the above-mentioned properties were insufficient so that the composition

was not suitable for the coating formation application.

Industrial Applicability

[0039]

In the curable composition according to the present invention, the cured coating comprises excellent water repellency, water sliding property and wear resistance, as well as excellent workability and storage stability. Consequently, the composition is useful for forming a thin coating layer for imparting a protective performance such as water repellency, water sliding property and durability to a metal surface, a painted surface, a resin surface or the like of an automobile body and a train carriage.

CLAIMS

1. A curable composition comprising:
 - (A) 100 parts by mass of a silicone resin having a viscosity of 50-500 mm²s⁻¹ at 25°C and having a hydrolysable reactive group;
 - (B) 1.0-30 parts by mass of an aluminum-based catalyst for condensation reaction; and
 - (C) 600-1700 parts by mass of an organic solvent which contains 40 mass% or more of a naphthene hydrocarbon compound and of which a boiling point (a temperature range from an initial boiling point to a dry point when the boiling point is not one temperature) falls within a range of 140-200°C.
2. The curable composition according to claim 1, wherein the boiling point of the (C) falls within a range of 142-175°C, and a temperature difference between the initial boiling point and the dry point is within 20°C.
3. The curable composition according to claim 1 or 2, wherein the curable composition forms a coating on a surface of a steel plate or a painted steel plate.
4. The curable composition according to claim 1 or 2, wherein the curable composition forms a coating on a surface of an automobile body.
5. A method for forming a coating by: applying the curable composition according to any one of claims 1-4 on a surface of an automobile body; volatilizing the (C) under a normal-temperature or heating environment; and then dry-wiping, or wet-wiping followed by dry-wiping, the surface.

6. A cured coating formed by the method for forming the coating according to claim 5.