(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
9 March 2017 (09.03.2017)

WIPO | PCT

(10) International Publication Number
WO 2017/036618 A1

(51) **International Patent Classification**:
C09J 183/04 (2006.01) ***C09J 183/14*** (2006.01)
C08K 3/36 (2006.01)

(21) **International Application Number**:
PCT/EP2016/062325

(22) **International Filing Date**:
1 June 2016 (01.06.2016)

(25) **Filing Language**: English

(26) **Publication Language**: English

(30) **Priority Data**:
2015-170986 31 August 2015 (31.08.2015) JP

(71) **Applicant**: **WACKER CHEMIE AG** [DE/DE]; Hanns-Seidel-Platz 4, 81737 München (DE).

(72) **Inventors**: **ASAKAWA, Yukihiko**; 187-135 Naka, Tsuchiura-shi, Ibaraki 300-0841 (JP). **ARAKI, Shinichi**; 3-13-1 Ninomiya, Tsukuba-shi, Ibaraki 305-0051 (JP). **HOSHINO, Kei**; 1-21-10 Matsushiro, Tsukuba-shi, Ibaraki 305-0035 (JP).

(74) **Agents**: **MIESKES, Klaus** et al.; Wacker Chemie AG, Hanns-Seidel-Platz 4, 81737 München (DE).

(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Published:

— *with international search report (Art. 21(3))*

WO 2017/036618 A1

(54) **Title**: SILICONE RUBBER COMPOSITION FOR AIRBAG SEALING MATERIAL

(57) **Abstract**: The present invention relates to a silicone rubber composition for an airbag sealing material that achieves an appropriate viscosity during coating and forms a cured product having excellent adhesion property and elongation.

SILICONE RUBBER COMPOSITION FOR AIRBAG SEALING MATERIAL

TECHNICAL FIELD

[0001]

The present invention relates to a silicone rubber composition for an airbag sealing material that achieves an appropriate viscosity during coating and forms a cured product having excellent adhesion property and elongation.

BACKGROUND ART

[0002]

An airbag is installed in a vehicle or the like, is used to protect a person in the vehicle against impact due to collision or roll, and has been improved. In recent years, the airbag has required accurate operation and stable actualization and maintenance of a function under a severe environment. In particular, the airbag has strongly required that sewing portions of base materials are accurately, certainly, and stably fit with each other.

[0003]

For example, Patent Literature 1 discloses an airbag in which edge portions of base materials made of two woven fabrics coated with a silicone-based material are bonded with a silicone-based elastic adhesive and sewn together with a thread to prevent the leakage of gas from the bonded portion. As such a silicone-based elastic adhesive, an addition reaction-curable silicone rubber composition is suitable. This is because the curing property of the composition can be easily controlled, the composition can be cured at room temperature or by slight heating, and a by-product cannot be produced during curing.

[0004]

Various types of materials for stabilizing the silicone rubber composition during storage and toughening the airbag by tightly bonding the silicone-coated base materials have been investigated. The materials are mixed in the silicone rubber

composition. For example, Patent Literature 2 discloses a silicone rubber composition in which a calcium carbonate powder surface-treated with a partially hydrolytic condensate of tetraalkoxysilane is mixed to prevent the generation of hydrogen gas during storage.

[0005]

In order to enhance the adhesion force with a base cloth, for example, Patent Literature 3 discloses a silicone rubber composition in which an alkaline earth metal carbonate powder substantially surface-treated with an organopolysiloxane is mixed, and Patent Literature 4 discloses a silicone rubber composition in which a calcium carbonate powder having a BET specific surface area of 5 to 50 m^2/g is mixed.

[0006]

However, the silicone rubber compositions have severe problems in which physical characteristics, particularly elongation, are significantly reduced when temperature and humidity are repeatedly changed over a long period. In a silicone rubber composition for an airbag sealing material, it is necessary to prevent deformation of an airbag due to sewing during production. Further, it is necessary that elongation after fracture of a cured product be not reduced so that the airbag can tolerate a rapid expansion due to a high gas pressure that is generated by operation of the airbag during collision, that is, it is preferable that the silicon rubber composition constantly have a high elongation of 900% or more. When the elongation is significantly reduced, a cured product layer of the silicone rubber composition does not tolerate a high-pressure gas generated in an inflator. As a result, the cured product layer is broken or released from the base cloth, resulting in the leakage of gas, which is a severe problem. In particular, when gas is generated in the inflator at a pressure that is higher than expected due to deterioration of an explosive in the inflator under high temperature and high humidity, there is a risk for making the problem more severe.

[0007]

In order to solve the problem, for example, Patent Literature 5 discloses a silicone rubber composition in which a quartz powder is mixed as the most suitable material. In order to impart a desired performance to the airbag, it is very important that the width and thickness of the cured product layer of the silicone rubber composition for an airbag sealing material can be controlled. Therefore, it is necessary that the silicone rubber composition for an airbag sealing material be efficiently applied to the base cloth so that the width and thickness are constant as designed. In Patent Literature 5, the silicone rubber composition in which the quartz powder is mixed to adjust the viscosity to about 100 Pa·s to about 500 Pa·s is used. This is because the silicone rubber composition having a relatively higher viscosity can be easily applied.

[0008]

In the related art, it is necessary that a large amount of quartz powder be mixed to adjust the viscosity to 100 Pa·s or more. However, in a silicone rubber composition in which the quartz powder is mixed in an amount that is equal to or more than the amount of dimethylpolysiloxane as a major agent, excellent characteristics of silicone rubber, in which the viscosity is decreased during shearing and rapidly restored during termination of shearing, are largely lost. For this reason, a raw material is difficult to be dispersed during production of the silicone rubber composition. When the silicone rubber composition is distributed into two liquids in advance and the two liquids are stored, the two liquids are difficult to be mixed. Therefore, it takes time to mix the liquids. When the mixed liquid is applied, the discharging rate of the mixed liquid from a coating device is low. Therefore, it takes time to apply the mixed liquid. In addition, dripping of the mixed liquid during discharging cannot be sufficiently prevented. Therefore, it is difficult that the mixed liquid is applied. Accordingly, there is a problem in which the silicone rubber composition cannot be

applied accurately so that the width and thickness are as designed.

[0009]

The quartz powder is stable to changes of temperature and humidity over a long period, but does not directly contribute to a curing reaction of silicone rubber. Therefore, there is a problem in which an increase in the amount of quartz powder to be mixed suppresses curing of the silicone rubber composition. When curing is insufficient, the adhesion property is reduced. In order to prevent a reduction in the adhesion property, an adhesion-imparting component such as a silane-coupling agent is mixed. However, the silane-coupling agent as the adhesion-imparting component, an organotitanium compound, an organozirconium compound, or the like, acts with a silanol group on the surface of silica micropowder that is mixed to improve the mechanical strength of the silicone rubber composition, or organohydrogenpolysiloxane as a cross-linker, to increase the viscosity with time. Therefore, when the silicone rubber composition is distributed into two liquids in advance and the two liquids are stored for a fixed period and then mixed, the viscosity is larger than the viscosity immediately after production. There is a problem in which the width and thickness of the applied silicone rubber composition are different from those immediately after production.

[0010]

Since the quarts powder has a density of about 2.7 g/cm^3, and is heavier than silicone rubber, an increase in the amount of the quartz powder to be mixed increases the weight of the silicone rubber composition. Therefore, there is a problem in which the weight of an airbag product is difficult to be reduced. Further, quartz has a Mohs hardness as high as 7. Therefore, there are problems in which a sewing needle is difficult to be stuck through the base cloth during sewing and is worn.

CITATION LIST PATENT LITERATURE

[0011]

Patent Literature 1: Japanese Patent Application Laid-Open No. 2001-001854

Patent Literature 2: Japanese Patent Application Laid-Open No. H10-060281

Patent Literature 3: Japanese Patent Application Laid-Open No. 2002-038016

Patent Literature 4: Japanese Patent Application Laid-Open No. 2002-285130

Patent Literature 5: Japanese Patent Application Laid-Open No. 2008-062882

SUMMARY OF INVENTION

TECHNICAL PROBLEM

[0012]

In the inventions described in the above-described literatures (Patent Literatures 1 to 5), the silicone rubber compositions have a thickening effect, but are unstable with time. In addition, any problem is caused during coating and the physical properties after curing are not excellent. Therefore, the silicone rubber compositions do not satisfy a request in which desired viscosity and stability are imparted and excellent physical properties for a sealing material are balanced, and therefore the problems are not solved.

[0013]

In view of the circumstances, an object of the present invention is to provide a silicone rubber composition for a sealing material of an airbag that is produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape that achieves desired viscosity and stability and has excellent physical properties for the sealing material in good balance, and high productivity. The silicone rubber composition prevents the leakage of air from the airbag.

Another object of the present invention is to provide a

silicone rubber composition for an airbag sealing material that effectively achieves a desired viscosity without addition of a large amount of quartz powder, has excellent physical properties for the sealing material in good balance, and high productivity.

Still another object of the present invention is to provide a silicone rubber composition for an airbag sealing material that hardly changes the viscosity with time even after storage and has high productivity.

SOLUTION TO PROBLEM

[0014]

The present inventors have intensively studied, and as a result, found that in a silicone rubber composition for a sealing material of an airbag that is produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape, when an appropriate polyether and/or a silane or siloxane compound having a silanol group is used with a quartz powder that can impart characteristics stable to repeated changes of temperature and humidity, an unexpected effect is obtained. Specifically, desired viscosity and stability are achieved and excellent physical properties for a sealing material are balanced, a desired viscosity can be effectively achieved without addition of a large amount of quartz powder and excellent physical properties for a sealing material are balanced, or the viscosity is hardly changed with time even after storage. Thus, the present invention has been completed.

[0015]

Specifically, a silicone rubber composition for an airbag sealing material of the present invention has the following configuration according to the three independent objects that are described in paragraph [0013].

(1) A silicone rubber composition for an airbag sealing material in which leakage of air from an airbag produced by bonding base cloths coated with silicone rubber and sewing the

base cloths together into a bag shape is prevented by sealing a portion of the bonded and sewn base cloths, the silicone rubber composition containing (A) a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule, (B) an organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule, (C) a silica micropowder having a specific surface area by a BET method of at least 50 m^2/g, (D) a quartz powder, (E) an effective amount of polyether, (F) a silane having at least one silanol group in one molecule or a siloxane compound having 2 to 20 silicon atoms and at least one silanol group in one molecule, and (G) an effective amount of an addition reaction-curing catalyst.

(2) A silicone rubber composition for an airbag sealing material in which leakage of air from an airbag produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape is prevented by sealing a portion of the bonded and sewn base cloths, the silicone rubber composition containing (A) a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule, (B) an organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule, the organohydrogenpolysiloxane containing an organohydrogenpolysiloxane having hydrogen atoms bonded to silicon atoms at both molecular chain terminals, (C) a silica micropowder having a specific surface area by a BET method of at least 50 m^2/g, (D) a quartz powder having an average particle diameter of 50 μm or less in an amount of 2 to 120 parts by mass relative to 100 parts by mass of the component (A), (E) an effective amount of a polyether, and (G) an effective amount of an addition reaction-curing catalyst, wherein the silicone rubber composition has a viscosity of 100 to 500 Pa·s at 25°C, and a cured product of the silicone rubber composition has an elongation after fracture of 900% or more.

(3) A silicone rubber composition for an airbag sealing material in which leakage of air from an airbag produced by

bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape is prevented by sealing a portion of the bonded and sewn base cloths, the silicone rubber composition containing (A) a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule, (B) an organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule, (C) a silica micropowder having a specific surface area by a BET method of at least 50 m^2/g, (D) a quartz powder having an average particle diameter of 50 μm or less in an amount of 2 to 120 parts by mass relative to 100 parts by mass of the component (A), (F) a silane having at least one silanol group in one molecule or a siloxane compound having 2 to 20 silicon atoms and at least one silanol group in one molecule in an amount of 0.02 to 20 parts by mass relative to 100 parts by mass of the component (A), and (G) an effective amount of an addition reaction-curing catalyst, wherein the silicone rubber composition has a function of stabilizing the viscosity of the silicone rubber composition with time.

[0016]

In the silicone rubber composition for an airbag sealing material, the organohydrogenpolysiloxane used as the component (B) preferably includes an organohydrogenpolysiloxane having hydrogen atoms bonded to silicon atoms at both molecular chain terminals.

[0017]

In the silicone rubber composition for an airbag sealing material, the quartz powder used as the component (D) preferably has an average particle diameter of 50 μm or less. JIS Z 8901 is used for the measurement of the particle diameter. The use amount of the quartz powder preferably falls within a range of 2 to 120 parts by mass relative to 100 parts by mass of the component (A).

[0018]

The silicone rubber composition for an airbag sealing

material preferably has a viscosity of 100 to 500 Pa·s at 25°C. The measurement was made with the apparatus Physica MCR301 of Anton Paar GmbH, Germany at a shear rate of $0.9s^{-1}$.

ADVANTAGEOUS EFFECTS OF INVENTION

[0019]

In the silicone rubber composition for an airbag sealing material of the present invention, a quartz powder is mixed and an appropriate polyether and/or a silane or siloxane compound having a silanol group are/is used. Thus, the silicone rubber composition for an airbag sealing material achieves desired viscosity and stability and has excellent physical properties for a sealing material in good balance, can effectively achieve a desired viscosity without addition of a large amount of quartz powder and has excellent physical properties for a sealing material in good balance, or hardly changes the viscosity with time even after storage.

In addition, the width and thickness of a cured product layer of the silicone rubber composition can be set with high precision. For this reason, the leakage of high-pressure gas generated in an inflator cannot occur, and the silicone rubber composition for an airbag sealing material has high quality.

[0020]

Next, the effects of the three kinds of compositions (1) to (3) described in paragraph [0015] will be described.

In the composition (1), a desired viscosity can be achieved by addition of a polyether without addition of a large amount of quartz powder. The viscosity change with time can be reduced even after storage by addition of a silanol group-containing compound. These effects may be additive. For this reason, the productivity of an airbag sealing material can be enhanced.

In the composition (2), a desired viscosity can be achieved by addition of a polyether without addition of a large amount of quartz powder. The elongation after fracture of a cured product can be increased by addition of a

polysiloxane having SiH groups at both terminals. When the particle diameter and amount of the quartz powder are controlled, dispersion during mixing can be facilitated, and a curing reaction of silicone is easy to proceed. In addition, the adhesion property can be enhanced. For this reason, the productivity of an airbag sealing material can be enhanced. The control of the particle diameter and amount of the quartz powder and the addition of polyether produce a synergistic effect to achieve a more appropriate viscosity. The composition (2) particularly exhibits excellent effects in terms of viscosity, elongation, and productivity.

In the composition (3), the viscosity change with time can be reduced even after storage by addition of a silanol group-containing compound. In addition, the effect is improved by the control of the amount of the silanol group-containing compound. When the particle diameter and amount of the quartz powder are controlled, the above-described effect works, and the productivity of an airbag sealing material can be enhanced. The composition (3) particularly exhibits excellent effects in terms of temporal viscosity stability and productivity.

DESCRIPTION OF EMBODIMENTS

[0021]

Hereinafter, the silicone rubber composition for an airbag sealing material according to the present invention will be described in detail.

[0022]

The silicone rubber composition according to the present invention includes three kinds of compositions for an airbag sealing material described in paragraph [0015].

The silicone rubber composition is designed so that the composition has physical properties suitable for a sealing material of an airbag that is produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape, that is, a function of preventing

the leakage of air from the airbag. In addition, the silicone rubber composition is designed so that a process suitable to form the sealing material for production of the airbag is performed.

Specifically, the silicone rubber composition is designed so as to have a specific composition that satisfies any requirement during production of the airbag among various important requirements such as suitable viscosity, temporal viscosity stability, adhesion property to the silicone-coating surface on the base cloth, curing property within one day, elongation, and density of the silicone rubber composition during coating.

[0023]

In the present invention, an airbag using the silicone rubber composition as a sealing material is also one of embodiments of the present invention.

In this case, requirements for the silicone rubber composition and an airbag base cloth are as described in paragraph [0022].

[0024]

(Component (A))

The component (A) is a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule. Specifically, the component (A) is a major agent of a silicone rubber composition having excellent rubber physical properties after curing and is a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule.

[0025]

The component (A) usually has an average composition formula of the following formula (1).

$R^1_aSiO_{(4-a)/2}$ (1)

In the formula (1), R^1s are substituted or unsbustituted monovalent hydrocarbon groups having 1 to 18 carbon atoms, and are the same or different, and a is 1.7 to 2.1.

[0026]

Among the monovalent hydrocarbon groups represented by R^1, at least two or more groups are selected from an alkenyl group such as a vinyl group, an allyl group, a propenyl group, an isopropenyl group, a butenyl group, an isobutenyl group, a hexenyl group, and a cyclohexenyl group, and the other group is a substituted or unsubstituted monovalent hydrocarbon group having 1 to 18 carbon atoms, and specifically selected from an alkyl group such as a methyl group, an ethyl group, a propyl group, an isopropyl group, a butyl group, an isobutyl group, a tert-butyl group, a pentyl group, a neopentyl group, a hexyl group, a 2-ethylhexyl group, a heptyl group, an octyl group, a nonyl group, a decyl group, and a dodecyl group, a cycloalkyl group such as a cyclopentyl group, a cyclohexyl group, and a cycloheptyl group, an aryl group such as a phenyl group, a tolyl group, a xylyl group, a biphenyl group, and a naphthyl group, an aralkyl group such as a benzyl group, a phenylethyl group, a phenylpropyl group, and a methylbenzyl group, and a halogen-substituted alkyl group and a cyano-substituted alkyl group such as a chloromethyl group, a 2-bromoethyl group, a 3,3,3-trifluoropropyl group, a 3-chloropropyl group, and a cyanoethyl group in which a part or all of the hydrogen atoms is substituted with a halogen atom or a cyano group.

[0027]

It is preferable that two or more alkenyl groups in R^1s to be selected be vinyl groups, and the other group be a methyl group, a phenyl group, or a 3,3,3-trifluoropropyl group. It is preferable that 70% by mole or more of all R^1s be a methyl group in terms of physical properties of a cured product and cost efficiency. For 80% by mole or more of all R^1s, a methyl group is usually used.

[0028]

In the formula (1), a is 1.7 to 2.1. The diorganopolysiloxane may be linear or branched. Examples of molecular structure of the component (A) may include a dimethylpolysiloxane having both molecular chain terminals capped with dimethylvinylsiloxy groups, a dimethylsiloxane-

methylphenylsiloxane copolymer having both molecular chain terminals capped with dimethylvinylsiloxy groups, a dimethylsiloxane-methylvinylsiloxane copolymer having both molecular chain terminals capped with dimethylvinylsiloxy groups, a dimethylsiloxane-methylvinylsiloxane-methylphenylsiloxane copolymer having both molecular chain terminals capped with dimethylvinylsiloxy groups, a dimethylsiloxane-methylvinylsiloxane copolymer having both molecular chain terminals capped with trimethylsiloxy groups, an organopolysiloxane including a siloxane unit represented by formula: $(CH_3)_2ViSiO_{1/2}$, a siloxane unit represented by formula: $(CH_3)_3SiO_{1/2}$, and a siloxane unit represented by formula: $SiO_{4/2}$ (wherein Vi represents a vinyl group), an organopolysiloxane in which a part or all of the methyl groups is substituted with an alkyl group such as an ethyl group and a propyl group, an aryl group such as a phenyl group and a tolyl group, or a halogenated alkyl group such as a 3,3,3-trifluoropropyl group, and a mixture of two or more kinds of these organopolysiloxanes. A linear diorganopolysiloxane is usually used.

[0029]

The diorganopolysiloxanes are produced by a method known to those of skill in the art. As the diorganopolysiloxane of the component (A), a diorganopolysiloxane having a viscosity of 5 to 500,000 mPa·s, and preferably 50 to 200,000 mPa·s at 25°C is used.

[0030]

(Component (B))

As the organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule of the component (B), for example, a methylhydrogenpolysiloxane, a dimethylsiloxane-methylhydrogensiloxane copolymer, a methylphenylsiloxane-methylhydrogensiloxane copolymer, a cyclic methylhydrogenpolysiloxane, or a copolymer including a dimethylhydrogensiloxy unit and a $SiO_{4/2}$ unit is used. It is

preferable that the amount of the component (B) to be mixed be such an amount that the ratio of the amount by mole of a silicon atom-bonded hydrogen atom in the organohydrogenpolysiloxane to the amount by mole of the alkenyl group in the component (A) be 1/5 to 20/1.

[0031]

In order to enhance the elongation of the cured product of the silicone rubber composition, it is preferable that the component (B) contain an organohydrogenpolysiloxane having hydrogen atoms bonded to silicon atoms at both molecular chain terminals, and more preferably an organohydrogenpolysiloxane having hydrogen atoms bonded to silicon atoms only at both molecular chain terminals. The organohydrogenpolysiloxanes may be linear, branched, or cyclic. The organohydrogenpolysiloxane may be used alone or two or more kinds thereof may be used. When two or more kinds thereof are used, cross-linking points in the cured product are likely to be unevenly distributed. Therefore, this is effective since the elongation of the cured product can be relatively easily increased.

[0032]

It is particularly preferable that the component (B) be used in combination with a dimethylpolysiloxane having both molecular chain terminals capped with alkenyl groups among dimethylpolysiloxanes selected as the component (A) described above. This is because silicone molecular chains in the silicone rubber composition are likely to be arranged in a certain direction, and therefore the molecule after curing is likely to be a long chain and the elongation of the cured product of the silicone rubber composition is increased. Examples of such a component (A) may include a dimethylpolysiloxane having both molecular chain terminals capped with dimethylvinylsiloxy groups, a dimethylsiloxane-methylphenylsiloxane copolymer having both molecular chain terminals capped with dimethylvinylsiloxy groups, and a dimethylsiloxane-methylvinylsiloxane copolymer having both

molecular chain terminals capped with dimethylvinylsiloxy groups.

[0033]

(Component (C))

Examples of the silica of the component (C) may include fumed silica, silica fume, precipitated silica, calcined silica, colloidal silica, and diatomaceous earth that are hydrophilic or hydrophobic. Micropowders thereof are preferred, and micropowders thereof having a particle diameter of 100 μm or less and a specific surface area of 50 m^2/g or more are more preferred. Further, silica that is surface-treated with an organosilane, an organosilazane, or an organocyclopolysiloxane in advance can be suitably used. The addition amount of the component (C) usually falls within a range of 0.5 to 100 parts by mass, and preferably 1 to 50 parts by mass, relative to 100 parts by mass of the component (A). The component (C) may be used alone or two or more kinds thereof may be used.

[0034]

When hydrophilic micropowder silica is used, it is preferable that the surface of silica be treated with a hydrophobizing agent, if necessary and used. Examples of the hydrophobizing agent may include an organosilazane such as hexamethyldisilazane, a halogenated silane such as methyltrichlorosilane, dimethyldichlorosilane, and trimethylchlorosilane, an organoalkoxysilane in which the halogen atom is substituted with an alkoxy group such as a methoxy group and an ethoxy group, and dimethyl silicone oil. Hexamethyldisilazane is preferred.

[0035]

(Component (D))

The quartz powder of the component (D) is an essential component of the present invention that imparts characteristics in which the silicone rubber composition is stable even after repeated changes of temperature and humidity over a long period, in particular, physical characteristics

such as elongation. It is preferable that the average particle particle diameter of the quartz powder be 50 μm or less, and more preferably 25 μm or less since the dispersion during mixing is facilitated. The addition amount of the quartz powder usually falls within a range of 2 to 120 parts by mass, and preferably 5 to 100 parts by mass, relative to 100 parts by mass of the component (A). When the addition amount is less less than 2 parts by mass, the addition effect is reduced. When it is more than 120 parts by mass, the curing reaction of silicone is difficult to proceed, and the adhesion property to the surface of the silicone cured product on the base cloth is reduced. Therefore, this is not preferred.

[0036]

(Component (E))

The polyether of the component (E) is a component of imparting characteristics that effectively increase the viscosity of the silicone rubber composition during addition of the quartz powder, and is an essential component in the configurations (1) and (2) described in paragraph [0015]. The component (E) is at least one polyether. The polyether may be an oligomer, a homopolymer, or a copolymer such as a block copolymer and a graft copolymer, and may be linear, branched, or cyclic. It is more preferable that the polyether be a polyoxyalkylene or an organopolysiloxane-polyoxyalkylene copolymer. The addition amount of the component (E) usually falls within a range of 0.01 to 10 parts by mass, and preferably 0.02 to 5 parts by mass, relative to 100 parts by mass of the component (A). When the addition amount is less than 0.01 parts by mass, the addition effect is reduced. When it is more than 10 parts by mass, the curing reaction of silicone is unlikely to proceed, and the adhesion property is reduced. Therefore, this is not preferred.

[0037]

The structure and molecular weight of polyoxyalkylene as the polyether of the component (E) is not limited.

Examples of the polyoxyalkylene may include, but are not

limited to, a poly(oxyethylene) having an average composition formula of the following formula (2), a poly(oxypropylene) having an average composition formula of the following formula (3), a poly(oxybutylene) having an average composition formula of the following formula (4), a poly(oxyethylene-oxypropylene) copolymer having an average composition formula of the following formula (5), and a cyclic polyoxyalkylene.

$$R^2O(CH_2CH_2O)_bR^2 \quad (2)$$

$$R^2O[CH_2CH(CH_3)O]_bR^2 \quad (3)$$

$$R^2O[CH_2CH(CH_2CH_3)O]_bR^2 \quad (4)$$

$$R^2O(CH_2CH_2O)_c[CH_2CH(CH_3)O]_dR^2 \quad (5)$$

In the formulae (2) to (5), R^2s are a hydrogen atom, R^3, or $-C(=O)-R^3$, and are the same or different. R^3 is a substituted or unsbustituted monovalent hydrocarbon group having 1 to 20 carbon atoms or a monovalent halogenated hydrocarbon group. b and (c + d) are such values that the average molecular weight of polyoxyalkylene is 20 to 4,000,000.

[0038]

The monovalent hydrocarbon group represented by R^3 has 1 to 20 carbon atoms, and preferably has 1 to 10 carbon atoms. Examples of the monovalent hydrocarbon group may include, but are not limited to, an alkyl group such as a methyl group, an ethyl group, a propyl group, a pentyl group, an octyl group, an undecyl group, and an octadecyl group; a cycloalkyl group such as a cyclohexyl group; an alkenyl group such as a vinyl group, an allyl group, a butenyl group, and a hexenyl group; an aryl group such as a phenyl group, a tolyl group, a xylyl group, a benzyl group, and a 2-phenylethyl group; and a halogenated hydrocarbon group such as a 3,3,3-trifluoropropyl group, a 3-chloropropyl group, and a dichlorophenyl group.

[0039]

Specific examples of the polyoxyalkylene as the polyether of the component (E) may include, but are not limited to, poly(ethylene glycol), poly(propylene glycol), poly(tetrahydrofuran), and ether and ester derivatives thereof, for example, a monomethyl ether, a dimethyl ether, and a

diacetate thereof; a series of poly(oxyethylene) sorbitan esters commercially available from ICI Americas Inc., as trade name Tween (registered trademark); and a series of nonylphenyl poly(ethylene glycol) ethers commercially available from Union Carbide as trade name TERGITOL NP (registered trademark).

[0040]

Specific examples thereof may include linear and multiple chain poly(oxyalkylene) glycols such as poly(butylene glycol), poly(oxyethylene)poly(oxypropylene) glycol, poly(oxyethylene glycerol), poly(glycerol), poly(oxypropylene glyceryl ether), poly(oxyethylene-polyoxypropylene glyceryl ether), poly(oxybutylene)poly(oxyethylene)poly(oxypropylene) glyceryl ether, poly(oxyethylene)poly(oxypropylene) trimethylolpropane, poly(oxypropylene) diglyceryl ether, poly(oxyethylene)poly(oxypropylene) pentaerythritol ether, sorbitol poly(oxypropylene), and poly(oxybutylene)poly(oxyethylene) pentaerythritol ether; linear and multiple chain poly(oxyalkylene) alkyl ethers such as poly(oxyethylene) monoalkyl ether, poly(oxypropylene) alkyl ether, poly(oxyethylene) cholesteryl ether, poly(oxyethylene)poly(oxypropylene) alkyl ether, poly(oxyethylene) methyl glucoside, poly(oxypropylene) methyl glucoside, and poly(oxybutylene)poly(oxyethylene)poly(oxypropylene) methyl glucoside; and linear and multiple chain poly(oxyalkylene) esters such as poly(oxyethylene) monoester, poly(propylene) glycol monoester, poly(butylene) glycol monoester, poly(oxyethylene) diester, poly(oxyethylene) alkyl ether ester, poly(oxytetramethylene) diester, poly(oxyethylene) fatty acid glyceryl, poly(oxyethylene) glyceryl isostearate, poly(oxyethylene) glyceryl triisostearate, poly(oxyethylene) trimethylol propane distearate, poly(oxyethylene) sorbitan monofatty acid ester, poly(oxyethylene) sorbitan fatty acid ester, poly(oxyethylene) hydrogenated castor oil, monofatty acid poly(oxyethylene) hydrogenated castor oil, poly(oxyethylene) hydrogenated castor oil succinate,

poly(oxyethylene) castor oil, poly(oxyethylene) sorbitol tetraoleate, poly(oxyethylene) sorbitol tetraisostearate, poly(oxyethylene) sorbitol isostearate, poly(oxyethylene) sorbitol pentaoleate, and poly(oxyethylene) methyl glucoside triisostearate.

[0041]

The polyether of the component (E) may be an organopolysiloxane-polyoxyalkylene copolymer. The organopolysiloxane-polyoxyalkylene copolymer is also referred to as "polyether-modified silicone" in the art, and has a polysiloxane backbone and pendant and/or terminal polyether groups. However, the silicone polyether copolymer may have an "inverted" structure. In this case, the copolymer has a polyether backbone and pendant and/or terminal polysiloxane groups. The polysiloxane and polyether groups in the silicone polyether may have a branched or unbranched structure.

The organopolysiloxane-polyoxyalkylene copolymer may or may not be hydrolyzable. In a hydrolyzable organopolysiloxane-polyoxyalkylene copolymer, the polyether group is bonded to the silicone via a hydrolytically unstable silicon-oxygen-carbon (Si-O-C) bond. In a non-hydrolyzable organopolysiloxane-polyoxyalkylene copolymer, the polyether group that is bonded to the silicone via a hydrolytically stable silicon-carbon (Si-C) bond may be used.

[0042]

The polyoxyalkylene group in the organopolysiloxane-polyoxyalkylene copolymer generally includes an oxyalkylene unit such as an oxyethylene unit ($-CH_2CH_2O-$), an oxypropylene unit ($-CH_2CH(CH_3)O-$), and an oxybutylene unit ($-CH_2CH(CH_2CH_3)O-$). The polyoxyalkylene group may include a single kind of oxyalkylene unit or a combination of a plurality of different units, for example, an oxyethylene unit and an oxypropylene unit.

[0043]

According to a preferable embodiment of the present invention, the organopolysiloxane-polyoxyalkylene copolymer

has an average composition formula of the following formula (6).

$$R^5R^4_2SiO(R^4_2SiO)_e(R^6R^4SiO)_fSiR^4_2R^5 \quad (6)$$

In the formula (6), each R^4 is a monovalent hydrocarbon group, R^5 is R^4 or R^6, and R^6 is a polyoxyalkylene group having an average composition formula selected from the following formulae (7) to (9).

$$-R^7O(CH_2CH_2O)_gR^8 \quad (7)$$

$$-R^7O[CH_2CH(CH_3)O]_hR^8 \quad (8)$$

$$-R^7O(CH_2CH_2O-)_i[CH_2CH(CH_3)O]_jR^8 \quad (9)$$

In the formulae, R^7 is a divalent hydrocarbon group having 2 to 20 carbon atoms, R^8 is selected from a hydrogen atom, an alkyl group having 1 to 4 carbon atoms, and an acyl group having 2 to 6 carbon atoms, e is 0 to 200, f is 1 to 100, and g, h, i, and j are each 1 to 60.

[0044]

It is preferable that the monovalent hydrocarbon groups represented by R^4 have 1 to 12 carbon atoms. Examples of the monovalent hydrocarbon groups may include, but are not limited to, an alkyl group such as a methyl group, an ethyl group, a propyl group, a butyl group, and an octyl group; a cycloalkyl group such as a cyclopentyl group and a cyclohexyl group; an alkenyl group such as a vinyl group, an allyl group, a butenyl group, and a hexenyl group; and an aryl group such as a phenyl group, a naphthyl group, a benzyl group, and a tolyl group. It is more preferable that all the monovalent hydrocarbon groups represented by R^4 be a methyl group in terms of the availability of starting materials.

[0045]

It is preferable that the divalent hydrocarbon group represented by R^7 have 2 to 6 carbon atoms. Examples of the divalent hydrocarbon group may include, but are not limited to, groups represented by the following formulae: $-CH_2CH_2CH_2-$, $-CH_2CH_2CH_2CH_2-$, $-CH_2CH(CH_3)-$, $-CH_2CH(CH_3)CH_2-$, and $CH_2CH_2CH_2CH_2CH_2-$. It is more preferable that the divalent hydrocarbon group represented by R^7 be a group represented by a formula: -

$CH_2CH_2CH_2$-.

[0046]

(Component (F))

The siloxane compound of the component (F) is a component of imparting a function of controlling the viscosity change of the silicone rubber composition with time, and is an essential component in the configurations (1) and (3) described in paragraph [0015]. The component (F) is a silane or siloxane compound having at least one silanol group (i.e., hydroxy group bonded to a silicon atom) in one molecule. The component (F) may be used alone or two or more kinds thereof may be used. The siloxane compound is an oligomer generally having 2 to 20 silicon atoms, preferably 2 to 10 silicon atoms, and more preferably 2 to 4 silicon atoms, and may have a linear, cyclic, or branched molecular structure.

[0047]

Examples of the component (F) may include silane such as trimethylsilanol, triethylsilanol, triisopropylsilanol, triphenylsilanol, dimethylphenylsilanol, vinylphenylmethylsilanol, and dimethylvinylsilanol, and an oligomer thereof; and a silanol-terminated polydimethylsiloxane, a silanol-terminated diphenylsiloxane-dimethylsiloxane copolymer, a silanol-terminated polydiphenylsiloxane, a silanol-terminated polytrifluoropropylmethylsiloxane, a 1-hydroxyheptamethylcyclotetrasiloxane, and an oligomer thereof.

[0048]

Examples of an organic group bonded to a silicon atom other than the silanol group in the component (F) may include unsubstituted and halogen-substituted monovalent hydrocarbon groups having 1 to 12 carbon atoms, and preferably about 1 to about 10 carbon atoms, as exemplified by R^1 in the average composition formula (1) of the component (A). Additional examples thereof may include epoxy-functional group-substituted alkyl groups such as a γ-glycidoxypropyl group and a β-(3,4-epoxycyclohexyl)ethyl group. Preferable example

thereof may include a methyl group, an ethyl group, a propyl group, a phenyl group, a vinyl group, and a γ-glycidoxypropyl group.

[0049]

The addition amount of the component (F) also depends on the molecular weight of the component (F), and is usually 0.02 to 20 parts by mass, and preferably 0.1 to 10 parts by mass, relative to 100 parts by mass of the component (A). When the addition amount is less than 0.02 parts by mass, the effect of controlling the viscosity of the silicone rubber composition with time is reduced. When it is more than 20 parts by mass, the physical properties of the cured product are reduced. Therefore, this is not preferred.

[0050]

(Component (G))

The addition reaction-curing catalyst of the component (G) is a catalyst that promotes an addition curing reaction of an alkenyl group with a hydrogen atom to be bonded to a silicon atom, and such a catalyst is well known to those of skill in the art. Examples of the component (G) may include a platinum group metal such as platinum, rhodium, palladium, osmium, iridium, and ruthenium, platinum group metals fixed on a particulate carrier material (e.g., activated carbon, aluminum oxide, and silicon oxide), and a platinum compound such as a platinum halide, a platinum-olefin complex, a platinum-alcohol complex, a platinum-alcoholate complex, a platinum-vinylsiloxane complex, dicyclopentadiene-platinum dichloride, cyclooctadiene-platinum dichloride, and cyclopentadiene-platinum dichloride.

[0051]

As the addition amount of the component (G), an effective amount according to desired curing temperature and curing time in this application is used. The effective amount means an amount that is sufficient to cure the silicone rubber composition into a rubber state and allow the cured product of the silicone rubber composition to exhibit target physical

properties, and does not exhibit harmful effects due to excess addition. Specifically, the effective amount is an amount that is sufficient to effectively promote an addition reaction of the alkenyl groups in the component (A) with the hydrogen atoms bonded to silicon atoms in the component (B) using a platinum atom-containing catalyst as the component (G) and sufficiently cure the silicone rubber composition. The optimum amount thereof is different according to various specific targets and curing conditions. The optimum amount may be usually a concentration of catalyst metal element of 0.5 to 1,000 ppm, preferably 1 to 500 ppm, and more preferably 1 to 100 ppm, relative to the total amount of the silicone rubber composition. When the addition amount is less than 0.5 ppm, the addition reaction is significantly slow. When it is more than 1,000 ppm, the cost is increased. Therefore, this is not preferred.

[0052]

In the composition (2) described in paragraph [0015], the viscosity of the silicone rubber composition is 100 to 500 Pa·s at 25°C, and the elongation after fracture of the cured product of the silicone rubber composition is 900% or more.

By the addition of the polyether as the component (E) and the control of the particle diameter and addition amount of the quartz powder as the component (D), the viscosity synergistically approaches a desired viscosity range of 100 to 500 Pa·s at 25°C. The viscosity can be controlled within the desired viscosity range by fine adjustment of other components.

[0053]

The composition (3) described in paragraph [0015] has a function of stabilizing the viscosity of the silicone rubber composition with time.

The viscosity immediately after production is stably maintained even after a certain period by an action of the silanol group-containing compound as the component (F). Stability of viscosity with time is exhibited when the ratio of the viscosity after 7 days at 30°C to the initial viscosity

is less than 1.5.

[0054]

In the silicone rubber composition of the present invention, as an optional component other than the components (A) to (G), any material conventionally known as an additive to silicone rubber can be used as long as the object of the present invention is not impaired. Examples of the additive may include an adhesion-imparting agent, a pigment, a dye, a curing inhibitor, a heat-resistance-imparting agent, a flame retarder, a conductivity-imparting agent, a radiation-shielding agent, an electromagnetic wave-shielding agent, a preservative, a stabilizer, an organic solvent, a plasticizer, and a fungicide. Specific examples may include an organopolysiloxane having a silicon atom-bonded hydrogen atom or an alkenyl group and no another functional group in one molecule, and a non-functional organopolysiloxane having no silicon atom-bonded hydrogen atom and no alkenyl group. The additive may be used alone or two or more kinds thereof may be used.

[0055]

As the adhesion-imparting agent, any organosilicon compound can also be used. It is preferable that the adhesion-imparting agent be an organosilicon compound having an epoxy group and a silicon atom-bonded alkoxy group in one molecule. It is more preferable that the adhesion-imparting agent be an organosilicon compound having at least one epoxy group and at least two or more silicon atom-bonded alkoxy groups since the adhesion is effectively exerted.

It is preferable that such an epoxy group be bonded to a silicon atom in a form of a glycidoxyalkyl group such as a glycidoxypropyl group or an epoxy group-containing cyclohexylalkyl group such as a 2,3-epoxycyclohexylethyl group and a 3,4-epoxycyclohexylethyl group. It is preferable that the silicon atom-bonded alkoxy group be a trialkylsilyl group such as a trimethylsilyl group and a triethylsilyl group, or an alkyldialkoxysilyl group such as a methyldimethoxysilyl

group, an ethyldimethoxysilyl group, a methyldiethoxysilyl group, and an ethyldiethoxysilyl group.

As a functional group other than the above-described groups, a functional group selected from an alkenyl group such as a vinyl group, a (meth)acryloxy group, a hydrosilyl group (SiH group), and an isocyanate group may be used.

[0056]

In addition to the organosilicon compound, an organometallic compound such as an organotitanium compound, an organozirconium compound, and an organoaluminum compound may be used as the adhesion-imparting agent. The organometallic compound is not limited as long as it can act as a condensation promoter for promoting adhesion. The organometallic compound is effective for combination with the organosilicon compound having an epoxy group and a silicon atom-bonded alkoxy group in one molecule.

[0057]

Examples of the organometallic compound may include a titanium-based condensation promoter including an organotitanate ester such as tetraisopropyl titanate and tetrabutyl titanate; and an organotitanium chelate compound such as titanium diisopropoxy(acetylacetonate), titanium diisopropoxy(ethylacetoacetate), titanium tetraacetylacetonate, and titanium tetraacetylacetate; a zirconium-based condensation promoter including an organozirconium ester such as zirconium tetrapropylate and zirconium tetrabutyrate; an organozirconium chelate such as zirconium tributoxy acetylacetonate, zirconium butoxy acetylacetonate bisethylacetoacetate, and zirconium tetraacetylacetonate; and an oxozirconium compound such as zirconium bis(2-ethylhexanoate) oxide and zirconium acetylacetonate(2-ethylhexanoate) oxide; and an aluminum-based condensation catalyst including an aluminum alcoholate such as aluminum triethylate, aluminum triisopropylate, and aluminum tri(sec-butyrate); an aluminum chelate compound such as aluminum diisopropoxy(ethylacetoacetate), aluminum

tris(ethylacetoacetate), and aluminum tris(acetylacetonate); and aluminum acyloxy compound such as hydroxy aluminum bis(2-ethylhexanoate).

[0058]

In addition to the organometallic compound, for example, an organic compound having an isocyanate group in one molecule may be used. The organic compound is not particularly limited as long as it has at least one or more isocyanate groups in one molecule. Examples thereof may include benzyl isocyanate, tolylene diisocyanate, triallyl isocyanurate, trimethyl hexamethylene diisocyanate, diphenylmethane diisocyanate, hexamethylene diisocyanate, butane diisocyanate, pentane diisocyanate, tetramethylene-1,4-diisocyanate, pentamethylene-1,5-diisocyanate, 2,2,4-trimethyl-hexamethylene-1,6-diisocyanate, lysine diisocyanate, isophorone diisocyanate, hydrogenated xylylene diisocyanate, hydrogenated diphenylmethane diisocyanate, 1,4-cyclohexane diisocyanate, 1,3-bis(isocyanatomethyl) cyclohexane, 4,4-dicyclohexylmethane diisocyanate, tris(3-trimethoxysilylpropyl)isocyanurate, tris(3-triethoxysilylpropyl)isocyanurate, tris(3-propoxysilylpropyl)isocyanurate, and a derivative and precursor thereof. The organic compound may be used alone or two or more kinds thereof may be used. The organic compound is effective for combination with the organosilicon compound having an epoxy group and a silicon atom-bonded alkoxy group in one molecule.

[0059]

Examples of the pigment may include titanium oxide, aluminosilicate, iron oxide, zinc oxide, calcium carbonate, carbon black, rare earth oxides, chromium oxide, a cobalt pigment, ultramarine, cerium silanolate, aluminum oxide, aluminum hydroxide, titanium yellow, barium sulfate, precipitated barium sulfate, and mixtures thereof.

[0060]

The curing inhibitor has an ability of adjusting the curing rate of the addition reaction. Examples thereof may

include an acetylenic compound, hydrazine, triazole, phosphine, and mercaptan. As a compound having a curing inhabitation effect, any curing inhibitor conventionally known in the art can be used. Examples of such a compound may include a phosphorous-containing compound such as triphenyl phosphine, a nitrogen-containing compound such as tributyl amine, tetramethyl ethylenediamine, and benzotriazole, a sulfur-containing compound, an acetylenic compound, a compound having two or more alkenyl groups, a hydroperoxy compound, and a derivative of maleic acid. A silane and silicone compound having an amino group may be used.

Specific examples thereof may include various types of "enyne" compounds such as 3-methyl-3-penten-1-yne and 3,5-dimethyl-3-hexen-1-yne; an acetylene-based alcohol such as 3,5-dimethyl-1-hexyn-3-ol, 1-ethynyl-1-cyclohexanol, and 2-phenyl-3-butyn-2-ol; known maleate such as dialkyl maleate, dialkenyl meleate, and dialkoxyalkyl meleate, fumarate such as dialkyl fumarate, dialkenyl fumarate, and dialkoxyalkyl fumarate; and cyclovinyl siloxane.

[0061]

Examples of the heat-resistance-imparting agent may include cerium hydroxide, cerium oxide, iron oxide, fumed titanium dioxide, and mixtures thereof.

[Examples]

[0062]

Hereinafter, the present invention will be described specifically with reference to Examples and Comparative Examples. However, the present invention is not limited to the following Examples. In Examples, part(s) represents part(s) by mass.

[0063]

<Preparation of Base Material 1-1>

23 parts of dimethylpolysiloxane having vinyl groups at both molecular chain terminals and having a viscosity of about 120,000 mPa·s at 25°C and 44 parts of dimethylpolysiloxane

having vinyl groups at both molecular chain terminals and having a viscosity of about 25,000 mPa·s at 25°C as the component (A), 8 parts of fumed silica having a specific surface area by BET method of about 200 m^2/g as the component (C), and 0.8 parts of a dimethylpolysiloxane solution containing a chloroplatinic acid-1,3-divinyltetramethyldisiloxane complex in a content of 1% by mass in terms of platinum atom as the component (G) were mixed by a mixer to prepare a high-viscosity liquid as a base material 1-1.

[0064]

<Preparation of Base Material 1-2>

A high-viscosity liquid having the same composition as in Preparation of Base Material 1-1 except that 8 parts of fumed silica having a specific surface area by BET method of about 300 m^2/g was used in place of the fumed silica having a specific surface area by BET method of about 200 m^2/g as the component (C) in the base material 1-1 was prepared as a base material 1-2.

[0065]

<Preparation of Base Material 2-1a>

21 parts of dimethylpolysiloxane having vinyl groups at both molecular chain terminals and having a viscosity of about 120,000 mPa·s at 25°C and 44 parts of dimethylpolysiloxane having vinyl groups at both molecular chain terminals and having a viscosity of about 25,000 mPa·s at 25°C as the component (A), 8 parts of fumed silica having a specific surface area by BET method of about 200 m^2/g as the component (C), 1 part of a dimethylsiloxane-methylhydrogensiloxane copolymer having a silicon atom-bonded hydrogen atom at side chain of molecular chain and having a viscosity of 200 mPa·s at 25°C (silicon atom-bonded hydrogen atom content: 0.18% by mass) and 2 parts of a dimethylsiloxane-methylhydrogensiloxane copolymer having silicon atom-bonded hydrogen atoms only at both molecular chain terminals and having a viscosity of 10 mPa·s at 25°C (silicon atom-bonded hydrogen atom content: 0.18%

by mass) as the component (B), and 0.05 parts of 1-ethynylcyclohexanol were mixed by a mixer to prepare a high-viscosity liquid as a base material 2-1a.

[0066]

<Preparation of Base Material 2-1b>

A high-viscosity liquid having the same composition as in Preparation of Base Material 2-1a except that 2 parts of a dimethylsiloxane-methylhydrogensiloxane copolymer having a silicon atom-bonded hydrogen atom at side chain of molecular chain and having a viscosity of 100 mPa·s at 25°C (silicon atom-bonded hydrogen atom content: 0.18% by mass) was used in place of 2 parts of the dimethylsiloxane-methylhydrogensiloxane copolymer having silicon atom-bonded hydrogen atoms only at both molecular chain terminals and having a viscosity of 10 mPa·s at 25°C (silicon atom-bonded hydrogen atom content: 0.18% by mass) as the component (B) in the base material 2-1a was prepared as a base material 2-1b.

[0067]

<Preparation of Base Material 2-2>

A high-viscosity liquid having the same composition as in Preparation of Base Material 2-1a except that 8 parts of fumed silica having a specific surface area by BET method of about 300 m^2/g was used in place of the fumed silica having a specific surface area by BET method of about 200 m^2/g as the component (C) in the base material 2-1a was prepared as a base material 2-2.

[0068]

To the base material 1-1 or 1-2, the components (D) and (E) were added to prepare a final preparation (high-viscosity liquid) derived from the base material 1-1 or 1-2. Similarly, to the base material 2-1a, 2-1b, or 2-2, the components (D) and (E) were added to prepare a final preparation (high-viscosity liquid) derived from the base material 2-1a, 2-1b, or 2-2. Both the final preparations were mixed at a ratio of 1:1 to prepare a final silicone rubber composition. The physical properties of the silicone rubber composition were

measured. The silicone rubber composition was cured, and the physical properties of the cured product were measured.

[0069]

<Evaluation Method of Composition for Airbag Sealing Material>

The silicone rubber composition according to the present invention is designed so that the composition has physical properties suitable for a sealing material for an airbag that is produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape, that is, a function of preventing the leakage of air from the airbag. In addition, the silicone rubber composition is designed so that a process suitable for forming a sealing material for production of an airbag is performed. Specifically, the silicone rubber composition is designed so as to have a specific composition that satisfies any requirement during production of an airbag among various important requirements such as suitable viscosity, temporal viscosity stability, adhesion property to a silicone-coating surface on a base cloth, curing property within one day, elongation, and density of the silicone rubber composition during coating.

Therefore, as an evaluation method, test methods in which the requirements are most effectively checked are used.

[0070]

<Test Methods>

The mixing viscosity of the silicone rubber composition was measured by Physica MCR 301 manufactured by Anton Paar GmbH at a shearing rate at 25°C of 0.9 (1/s). A high-viscosity liquid was obtained by mixing the final preparation (high-viscosity liquid) derived from the base material 1-1 or 1-2 and the final preparation (high-viscosity liquid) derived from the base material 2-1a, 2-1b, or 2-2 at a ratio of 1:1 immediately after production, and a high-viscosity liquid was obtained by storing the final preparation (high-viscosity liquid) derived from the base material 1-1 or 1-2 and the final preparation (high-viscosity liquid) derived from the base material 2-1a, 2-1b, or 2-2 at 30°C for 7 days followed by

mixing at a ratio of 1:1. The viscosities of the resulting high-viscosity liquids were measured.

A curing sheet having a thickness of 2 mm was cured at 25°C for 24 hours to prepare a cured solid. The density and elongation after fracture of the cured solid were measured.

[0071]

The high-viscosity liquid obtained by storing the final preparation (high-viscosity liquid) derived from the base material 1-1 or 1-2 and the final preparation (high-viscosity liquid) derived from the base material 2-1a, 2-1b, or 2-2 at 30°C for 7 days followed by mixing at a ratio of 1:1 was cured, and the presence or absence of adhesion property thereof was confirmed. An addition curable-silicone rubber (ELASTOSIL LR6200 A/B, available from Wacker Chemie AG) was first applied to a polyamide woven fabric with a fiber diameter of 350 dtex by a knife coater, and cured in a drying furnace at 180°C for 1 minute to prepare two silicone-coated base materials. The silicone rubber composition was applied to one of the two base materials so that the width was about 10 mm and the thickness was about 1.0 mm, and the other base material was bonded to the base material so that the silicone-coated surface was in contact with the applied silicone rubber composition to prepare a test piece. The test piece was allowed to stand at 25°C for 24 hours. The curing state and adhesion state of the test piece were observed. The peel strength of the test piece was measured at a tensile rate of 200 mm/min.

[0072]

<Example 1>

76 parts of the base material 1-1, 25 parts of quartz powder having an average particle diameter of 50 μm (component (D)), 0.02 parts of polyethylene glycol having a viscosity of about 400 mPa·s at 25 °C (component (E)), 0.05 parts of polyether-modified silicone having a viscosity of about 800 mPa·s at 25°C represented by a formula (10) (component (E)):

$$(CH_3)_3SiO((CH_3)_2SiO)_{65}(R^9CH_3SiO)_7Si(CH_3)_3 \quad (10)$$

(wherein R^9 is $(CH_2)_3O(OCH_2CH_2)_{22}(OCH_2CH(CH_3))_{22}H$), and 0.1 parts

of trimethylsilanol (component (F)) were mixed to prepare a mixture as the final preparation derived from the base material 1-1. 76 parts of the base material 2-1a, 25 parts of quartz powder having an average particle diameter of 50 μm (component (D)), 0.02 parts of polyethylene glycol having a viscosity of about 400 mPa·s at 25 °C (component (E)), 0.05 parts of polyether-modified silicone having a viscosity of about 800 mPa·s at 25°C represented by a formula (2), and 0.1 parts of trimethylsilanol (component (F)) were sufficiently mixed to prepare a mixture as the final preparation derived from the base material 2-1a.

The final preparation derived from the base materials 1-1 and 2-1a were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0073]

<Example 2>

The final preparations derived from the base materials 1-1 and 2-1a were prepared in the same manner as in Example 1 except that only 0.07 parts of the polyether-modified silicone represented by the formula (10) was used and the polyethylene glycol having a viscosity of about 400 mPa·s at 25°C was not used as the polyether of the component (E).

The final preparations derived from the base materials 1-1 and 2-1a were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0074]

<Example 3>

The final preparations derived from the base materials 1-1 and 2-1a were prepared in the same manner as in Example 2 except that the silane having at least one silanol group in one molecule or the siloxane compound having 2 to 20 silicon atoms and at least one silanol group in one molecule was not used as the component (F).

The final preparations derived from the base materials 1-1 and 2-1a were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0075]

<Example 4>

The final preparations derived from the base materials 1-1 and 2-1a were prepared in the same manner as in Example 1 except that the amount of the quartz powder having an average particle diameter of 50 μm was changed from 25 parts to 40 parts, the polyether as the component (E) was not used, the addition amount of the silane having at least one silanol group in one molecule or the siloxane compound having 2 to 20 silicon atoms and at least one silanol group in one molecule as the component (F) was changed from 0.1 parts to 0.3 parts.

The final preparations derived from the base materials 1-1 and 2-1a were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0076]

<Example 5>

The final preparations derived from the base materials 1-1 and 2-1a were prepared in the same manner as in Examples 1 and 2 except that the polyether as the component (E) was not used.

The final preparations derived from the base materials 1-1 and 2-1a were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0077]

Example 6

The final preparations derived from the base materials 1-1 and 2-1b were prepared in the same manner as in Example 2 except that the base material 2-1b was used in place of the base material 2-1a.

The final preparations derived from the base materials 1-1 and 2-1b were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0078]

<Example 7>

The final preparation derived from the base material 1-2 was prepared in the same manner as in Example 1 except that the base material 1-2 was used in place of the base material 1-1 and the final preparation derived from the base material 2-2 was prepared in the same manner as in Example 1 except that the base material 2-2 was used in place of the base material 2-1a.

The final preparations derived from the base materials 1-

2 and 2-2 were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product ere measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0079]

<Example 8>

The final preparations derived from the base materials 1-1 and 2-1a were prepared in the same manner as in Example 1 except that 25 parts of quartz powder having an average particle diameter of 5 μm was used in place of 25 parts of the quartz powder having an average particle diameter of 50 μm as the component (D).

The final preparations derived from the base materials 1-1 and 2-1a were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0080]

<Comparative Example 1>

The final preparations derived from the base materials 1-1 and 2-1a were prepared in the same manner as in Example 4 except that the amount of the quartz powder as the component (D) was changed to 88 parts that corresponded to an amount of 130 parts relative to 100 parts of the component (A).

The final preparations derived from the base materials 1-1 and 2-1a were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of

measurement of physical properties are shown in Tables 1, 2, and 3.

[0081]

Comparative Example 2

The final preparations derived from the base materials 1-1 and 2-1b were prepared in the same manner as in Example 6 except that the polyether as the component (E) and the silane having at least one silanol group in one molecule or the siloxane compound having 2 to 20 silicon atoms and at least one silanol group in one molecule as the component (F) were not used.

The final preparations derived from the base materials 1-1 and 2-1b were mixed, and the physical properties of the mixture were measured by the method described above. The mixture was cured, and the physical properties of the cured product were measured by the method described above. The addition amount of each component and the results of measurement of physical properties are shown in Tables 1, 2, and 3.

[0082]

In Example 1, the polyethylene glycol, the polyether-modified silicone having an oxyethylene unit ($-CH_2CH_2O-$) and an oxypropylene unit ($-CH_2CH(CH_3)O-$), and the trimethylsilanol were mixed. As a result, the mixing viscosity immediately after production was 170 Pa·s at 25°C, and this viscosity satisfies a desired viscosity of 100 Pa·s or more. The viscosity after 7-day storage was 175 Pa·s at 25°C, which was hardly changed from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 74 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3 and the elongation after fracture was 980%.

[0083]

In Example 2, only the polyether-modified silicone having an oxyethylene unit (-CH_2CH_2O-) and an oxypropylene unit (-$CH_2CH(CH_3)O$-), and the trimethylsilanol were added. The mixing viscosity immediately after production was 150 Pa·s at 25°C. The viscosity after 7-day storage was 155 Pa·s at 25°C, which was hardly changed from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 68 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3 and the elongation after fracture was 980%.

[0084]

In Example 3, the silane having at least one silanol group in one molecule or the siloxane compound having 2 to 20 silicon atoms and at least one silanol group in one molecule as the component (F) was not added. The mixing viscosity immediately after production was 160 Pa·s at 25°C. The viscosity after 7-day storage was 250 Pa·s at 25°C, which was increased immediately after production. However, the viscosity did not affect coating. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 65 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3 and the elongation after fracture was 990%.

[0085]

In Example 4, the polyether as the component (E) was not contained, but the amount of the quartz powder as the component (D) was increased. The mixing viscosity immediately after production was thus 160 Pa·s at 25°C. The viscosity after 7-day storage was 160 Pa·s at 25°C, which was hardly changed

from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 70 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.3 g/cm^3 and the elongation after fracture was 910%.

[0086]

In Example 5, the polyether as the component (E) was not contained. Thus, the mixing viscosity immediately after production was 85 Pa·s at 25°C, which did not achieve the desired viscosity of 100 Pa·s. However, the viscosity did not affect coating. The viscosity after 7-day storage was 85 Pa·s at 25°C, which was hardly changed from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. Since the viscosity was low, the thickness of the coated part was decreased. The peel strength was decreased to 16 N/cm. The peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3 and the elongation after fracture was 980%.

[0087]

In Example 6, the mixing viscosity immediately after production was 145 Pa·s at 25°C. The viscosity after 7-day storage was 145 Pa·s at 25°C, which was hardly changed from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 65 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3. The elongation after fracture was decreased to 700% since the component (B)

did not contain an organohydrogenpolysiloxane having hydrogen atoms bonded to silicon atoms at both molecular chain terminals.

[0088]

In Example 7, the mixing viscosity immediately after production was 149 Pa·s at 25°C. The viscosity after 7-day storage was 153 Pa·s at 25°C, which was hardly changed from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 75 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3 and the elongation after fracture was 910%.

[0089]

In Example 8, the mixing viscosity immediately after production was 150 Pa·s at 25°C. The viscosity after 7-day storage was 155 Pa·s at 25°C, which was hardly changed from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 71 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3 and the elongation after fracture was 920%.

[0090]

In Comparative Example 1, the mixing viscosity immediately after production was 220 Pa·s at 25°C. The viscosity after 7-day storage was 230 Pa·s at 25°C, which was hardly changed from the viscosity immediately after production. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was not completely cured after 24 hours, and was hardly bonded to the cured silicone on the polyamide woven fabric. The peel

strength was 5 N/cm or less, and the peel state was 100% interfacial peeling. In terms of the physical properties of the cured product sheet, the density was 1.4 g/cm^3 and the elongation after fracture was decreased to 600%.

[0091]

In Comparative Example 2, the viscosity immediately after production was 80 Pa·s at 25°C, which did not achieve the desired viscosity of 100 Pa·s. However, the viscosity did not affect coating. The viscosity after 7-day storage was increased to 143 Pa·s at 25°C. The silicone rubber composition that was applied onto the cured silicone-coated surface on the polyamide woven fabric was cured after 24 hours, and bonded to the cured silicone on the polyamide woven fabric. The peel strength was 70 N/cm, and the peel state was 100% cohesive failure. In terms of the physical properties of the cured product sheet, the density was 1.2 g/cm^3 and the elongation after fracture was decreased to 600%.

[0092]

[Table 1]

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Comp. Example 1	Comp. Example 2
Base Material		1-1 2-1a	1-1 2-1a	1-1 2-1a	1-1 2-1a	1-1 2-1a	1-1 2-1b	1-2 2-2	1-1 2-1a	1-1 2-1a	1-1 2-1b
Addition Amount of Each Component (Part By Mass)	Component (A)	132	132	132	132	132	132	132	132	132	132
	Component (B)	3	3	3	3	3	3	3	3	3	3
	Component (C)	16	16	16	16	16	16	16	16	16	16
	Component (D)	50	50	50	80	50	50	50	50	176	50
	Component (E)	0.14	0.14	0.14	-	-	0.14	0.14	0.14	-	-
	Component (F)	0.2	0.2	-	0.6	0.2	0.2	0.2	0.2	0.6	-
	Component (G) (In Terms of Platinum Atom)	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008

[0093]

[Table 2]

	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Comp. Example 1	Comp. Example 2
Presence or Absence of Polysiloxane Having SiH Groups at Both Terminals in Component (B)	Presence	Presence	Presence	Presence	Presence	Absence	Presence	Presence	Presence	Absence
Bet Specific Surface Area of Component (C) (m^2/g)	Approx. 200	Approx. 200	Approx. 200	Approx. 200	Approx. 200	Approx. 200	Approx. 300	Approx. 200	Approx. 200	Approx. 200
Particle Diameter of Component (D) (μm)	50	50	50	50	50	50	50	5	50	50
Polyoxyalkylene in Component (E) (Part By Mass)	0.07	-	-	-	-	-	0.07	0.07	-	-
Organopolysiloxane-*Polyoxyalkylene Copolymer* in Component (E) (Part By Mass)	0.07	0.14	0.14	-	-	0.14	0.07	0.07	-	-

[0094]

[Table 3]

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Comp. Example 1	Comp. Example 2
Viscosity (Pa·s) (0.9/s, 25°C)	Immediately After Production	170	150	160	160	85	145	149	150	220	80
	After 7-Day Storage At 30°C	175	155	250	160	85	145	153	155	230	143
Curing Property (After 24 Hours)		Cured	Cured	Cured	Cured	Cured	Cured	Cured	Cured	Including Uncured Part	Cured
Density (g/cm³)		1.2	1.2	1.2	1.3	1.2	1.2	1.2	1.2	1.4	1.2
Elongation After Fracture (%)		990	980	990	910	980	700	910	920	600	600
Adhesion to Silicone-Cured Surface on Polyamide Cloth		Adhered	Adhered	Adhered	Adhered	Adhered	Adhered	Adhered	Adhered	Unadhered	Adhered
Peel Strength (N/cm)		74	68	65	70	16	65	75	71	≤5	70
Peel State		Cohesive Failure	Cohesive Failure	Cohesive Failure	Cohesive Failure	Cohesive Failure	Cohesive Failure	Cohesive Failure	Cohesive Failure	Interfacial Peeling	Cohesive Failure

Industrial Applicability

[0095]

In the silicone rubber composition for an airbag sealing material of the present invention, physical characteristics are not reduced by repeated changes of temperature and humidity over a long period, the viscosity change with time is reduced, and the cured product layer of the silicone rubber composition can be designed so that the width and thickness are always as designed. For this reason, the silicone rubber composition is a material suitable as a high-quality airbag sealing material in which the leakage of high-pressure gas generated in an inflator cannot occur.

CLAIMS

1. A silicone rubber composition for an airbag sealing material in which leakage of air from an airbag produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape is prevented by sealing a portion of the bonded and sewn base cloths, the silicone rubber composition comprising:

(A) a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule;

(B) an organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule;

(C) a silica micropowder having a specific surface area by a BET method of at least 50 m^2/g;

(D) a quartz powder;

(E) an effective amount of polyether;

(F) a silane having at least one silanol group in one molecule or a siloxane compound having 2 to 20 silicon atoms and at least one silanol group in one molecule; and

(G) an effective amount of an addition reaction-curing catalyst.

2. The silicone rubber composition for an airbag sealing material according to claim 1, wherein:

the quartz powder used as the component (D) has an average particle diameter of 50 μm or less and is contained in an amount of 2 to 120 parts by mass relative to 100 parts by mass of the component (A);

the polyether used as the component (E) is contained in an amount of 0.01 to 10 parts by mass relative to 100 parts by mass of the component (A); and

the silicone rubber composition has a viscosity of 100 to 500 Pa·s at 25°C.

3. A silicone rubber composition for an airbag sealing material in which leakage of air from an airbag produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape is prevented by sealing a portion of the bonded and sewn base cloths, the silicone

rubber composition comprising:

(A) a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule;

(B) an organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule, the organohydrogenpolysiloxane containing an organohydrogenpolysiloxane having hydrogen atoms bonded to silicon atoms at both molecular chain terminals;

(C) a silica micropowder having a specific surface area by a BET method of at least 50 m^2/g;

(D) a quartz powder having an average particle diameter of 50 μm or less in an amount of 2 to 120 parts by mass relative to 100 parts by mass of the component (A);

(E) an effective amount of a polyether; and

(G) an effective amount of an addition reaction-curing catalyst, wherein

the silicone rubber composition has a viscosity of 100 to 500 Pa·s at 25°C, and a cured product of the silicone rubber composition has an elongation after fracture of 900% or more.

4. A silicone rubber composition for an airbag sealing material in which leakage of air from an airbag produced by bonding base cloths coated with silicone rubber and sewing the base cloths together into a bag shape is prevented by sealing a portion of the bonded and sewn base cloths, the silicone rubber composition comprising:

(A) a diorganopolysiloxane having two or more alkenyl groups to be bonded to silicon atoms in one molecule;

(B) an organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule;

(C) a silica micropowder having a specific surface area by a BET method of at least 50 m^2/g;

(D) a quartz powder having an average particle diameter of 50 μm or less in an amount of 2 to 120 parts by mass relative to 100 parts by mass of the component (A);

(F) a silane having at least one silanol group in one molecule or a siloxane compound having 2 to 20 silicon atoms

and at least one silanol group in one molecule in an amount of 0.02 to 20 parts by mass relative to 100 parts by mass of the component (A); and

(G) an effective amount of an addition reaction-curing catalyst, wherein the silicone rubber composition has a function of stabilizing a viscosity of the silicone rubber composition with time.

5. The silicone rubber composition for an airbag sealing material according to any one of claims 1 to 3, wherein the polyether of the component (E) is any a polyoxyalkylene and/or an organopolysiloxane-polyoxyalkylene copolymer.

6. The silicone rubber composition for an airbag sealing material according to any one of claims 1, 2, 4, and 5, wherein the organohydrogenpolysiloxane having two or more hydrogen atoms to be bonded to silicon atoms in one molecule as the component (B) contains an organohydrogenpolysiloxane having hydrogen atoms bonded to silicon atoms at both molecular chain terminals.

7. An air bag comprising a cured product of the silicone rubber composition according to any one of claims 1 to 6.

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/062325

A. CLASSIFICATION OF SUBJECT MATTER
INV. C09J183/04 C08K3/36 C09J183/14
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
C09J C08K C08G

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 2007/129777 A1 (DOW CORNING TORAY CO LTD [JP]; TAKUMAN OSAMU [JP]; TASAKI TOMOKO [JP];) 15 November 2007 (2007-11-15)	1-7
Y	paragraphs [0001], [0035] example 1	1-3,5
Y	WO 2007/039763 A1 (DOW CORNING LTD [GB]; DOW CORNING TAIWAN INC) 12 April 2007 (2007-04-12) tables 1-4	1-3,5

☐ Further documents are listed in the continuation of Box C.

☒ See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
12 July 2016	18/07/2016

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Queste, Sébastien

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/062325

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