

CHLORINE-BASED RUBBER COMPOSITION, ELECTRIC WIRE, AND CABLE

CROSS-REFERENCE TO RELATED APPLICATION

The present application claims priority from Japanese
5 Patent Application No. 2024-99538 filed on June 20, 2024, the
content of which is hereby incorporated by reference into this
application.

TECHNICAL FIELD OF THE INVENTION

10 The present invention relates to a chlorine-based rubber
composite, an electric wire, and a cable.

BACKGROUND OF THE INVENTION

Rubber materials are principally used as coating members
15 for electric wires/cables, particularly as coating members for
mobile applications requiring flexibility and durability. Among
the rubber materials, chlorine-based rubbers are known as high-
functional materials excellent in flame retardancy and oil
resistance. In not only the chlorine-based rubbers but also the
20 rubber coating materials, there is the strong demand to decrease
the tackiness (adhesiveness) of the surface of the coating
material for the electric wire/cable in view of workability and
stable handleability.

For example, Japanese Patent Laid-Open No. 2023-121558
25 (Patent Document 1) discloses a silane crosslinked rubber
composite which is a silane crosslinked substance of a silane-
grafted rubber composite obtained by grafting a base polymer made
of mixture of a chlorinated polyethylene and an ethylene-based
copolymer resin under use of a silane coupling agent.

30

SUMMARY OF THE INVENTION

However, the desired adhesiveness improving effect is not

often obtained.

The present invention has been made in consideration of the above description, and an object of the present invention is to provide a chlorine-based rubber composite, an electric wire, and a cable, configured to decrease adhesiveness.

Other objects and novel characteristics will be apparent from the description of the present specification and the accompanying drawings.

A chlorine-based rubber composite according to one aspect of the present invention includes: a base polymer containing a chlorine-based rubber; and a silicone lubricant grafted with an acryl group, and a content of the silicone lubricant is equal to or more than 0.5 parts by mass and equal to or less than 5 parts by mass per 100 parts by mass of the base polymer.

One aspect of the present invention can provide a chlorine-based rubber composite, an electric wire, and a cable, configured to decrease adhesiveness.

BRIEF DESCRIPTIONS OF THE DRAWINGS

FIG. 1 is a cross-sectional schematic view of an electric wire and a cable;

FIG. 2 is a schematic view of a cable extruding step; and

FIG. 3 is a schematic view of measurement of a friction coefficient.

DESCRIPTIONS OF THE PREFERRED EMBODIMENTS

For decreasing the tackiness (adhesiveness) of the surface of the material for the electric wire/cable, provision of crystallinity to a rubber molecule, blending with a crystalline resin, and the like are considered to be effective. However, the provision of the crystalline component decreases the flexibility which is originally the feature of the rubber material.

Therefore, it is effective to add a powerful lubricant such as a silicone-based compound. However, such a lubricant is poor in compatibility particularly with a chlorine-based rubber material, and is difficult to be sufficiently dispersed in the composite.

5 A lubricant simply having a silicone backbone has insufficient compatibility with the chlorine-based rubber composite. Thus, the inventors of the present application have studied use of a compound in which the silicone backbone is graft-polymerized with an acryl group, as a lubricant having both
10 the silicone backbone and a polar group. Further, the inventors of the present application have studied the practical effect of decreasing the adhesiveness of the electric-wire/cable coating member, and the influence of the provision of excessive lubrication on actual electric-wire/cable manufacturing. As a
15 result, the inventors of the present application have found a range of an addition amount of the compound in which the silicone backbone is graft-polymerized with the acryl group, to the chlorine-based rubber composite.

Hereinafter, embodiments will be described in detail with
20 reference to the accompanying drawings. Note that components having the same function are denoted with the same reference symbols throughout all the drawings for describing the embodiments, and the repetitive description thereof will be omitted. In addition, the description of the same or similar
25 portions is not repeated in principle unless otherwise particularly required in the following embodiments.

<<Chlorine-Based Rubber Composite>>

A chlorine-based rubber composite according to one embodiment is described. The chlorine-based rubber composite
30 according to the present embodiment includes a base polymer and a silicone lubricant.

The chlorine-based rubber composite of the present

embodiment can be used for coating an electric wire or a cable.

<Base Polymer>

The base polymer according to the present embodiment includes a chlorine-based rubber. Although not particularly
5 limited, examples of the chlorine-based rubber are chlorinated polyethylenes, polychloroprenes, chlorosulfonated polyethylenes and the like. The chlorine-based rubber is preferably at least one or more selected from chlorinated polyethylenes, polychloroprenes, and chlorosulfonated polyethylenes. The
10 chlorine-based rubber is preferably a chlorinated polyethylene. In view of improving the abrasion resistance, a crystallization-grade chlorinated polyethylene is preferably used as the chlorinated polyethylene. A chlorine content of the chlorinated polyethylene is preferably equal to or more than 20% by mass and
15 equal to or less than 45% by mass. The Mooney viscosity of the chlorinated polyethylene is preferably equal to or less than 120. In view of a balance between the flame retardancy and the flexibility, the chlorine content of the chlorinated polyethylene is more preferably equal to or more than 25% by mass and equal
20 to or less than 40% by mass. The Mooney viscosity of the chlorinated polyethylene is more preferably equal to or less than 90.

The base polymer may further include a polymer other than the chlorine-based rubber. Examples of the polymer other than
25 the chlorine-based rubber are ethylene-based copolymers. Examples of the ethylene-based copolymers are ethylene-vinyl acetate copolymers, ethylene-methyl acrylate copolymers, ethylene-ethyl acrylate copolymers, ethylene-propylene copolymers, ethylene propylene diene copolymers, modified
30 products or mixtures thereof, and the like. In such an ethylene vinyl acetate copolymer, a vinyl acetate group which is a polar group can exhibit high compatibility with the chlorine of the

chlorine-based rubber molecule. Therefore, the ethylene-based copolymer is preferably the ethylene-vinyl acetate copolymer.

The melting point of the ethylene-based copolymer is, for example, equal to or higher than 70°C. The melting point of the ethylene-based copolymer is preferably equal to or higher than 80°C, and more preferably equal to or higher than 85°C. As the physical property of the ethylene-based copolymer resin, although not limited, a melt mass-flow rate (MFR) is, for example, equal to or less than 6 g/10 min. In view of improving the abrasion resistance, the physical property of the ethylene-based copolymer resin is preferably equal to or less than 1 g/10 min.

The base polymer preferably has a crosslinked structure. The base polymer preferably has a silane crosslinked structure. The silane crosslinked structure can be formed by silane-crosslinking the base polymer under use of a silane coupling agent. The silane coupling agent is, for example, a general-purpose silane coupling agent having both an organic functional group such as a vinyl group, a methacryl group, an acryl group, a styryl group, an amino group, or an epoxy group, and an alkoxy group such as a methoxy group or an ethoxy group. Specific examples thereof are vinyltrimethoxysilane, vinyltriethoxysilane, 3-methacryloxypropyltrimethoxysilane, 3-methacryloxypropyltriethoxysilane, methacryloxypropylmethyldimethoxysilane, methacryloxypropylmethyldiethoxysilane, acryloxypropyltrimethoxysilane, p-styryltrimethoxysilane, N-(2-aminoethyl)-3-aminopropylmethyldimethoxysilane, N-(2-aminoethyl)-3-aminopropyltrimethoxysilane, 3-aminopropyltrimethoxysilane, 3-aminopropyltriethoxysilane, triethoxysilyl-N-(1,3-dimethyl-butylidene)propylamine, N-phenyl-3-aminopropyltrimethoxysilane, N-(vinylbenzyl)-2-aminoethyl-3-aminopropyltrimethoxysilane hydrochloride, 2-(3,4-

epoxycyclohexyl)ethyltrimethoxysilane, 3-
glycidoxypropylmethyldimethoxysilane, 3-
glycidoxypropyltrimethoxysilane, 3-
glycidoxypropylmethyldiethoxysilane, 3-
5 glycidoxypropyltriethoxysilane, and mixtures thereof. However,
the silane coupling agent is not limited to the above-described
compounds at all, and may be an alkoxy oligomer as long as the
silane coupling agent has both the organic functional group and
the alkoxy group described above.

10 <Silicone Lubricant>

In the present embodiment, a silicone lubricant grafted
with an acryl group is added. By the addition of the silicone
lubricant grafted with the acryl group, the adhesiveness of the
chlorine-based rubber composite can be more reliably decreased.
15 In other words, sufficient lubrication can be provided to the
chlorine-based rubber composite. As a result, the effect of
cancelling the stress applied to the chlorine-based rubber
composite in the abrasion can be improved. As a result, the
abrasion resistance of the chlorine-based rubber composite can
20 be improved.

In the present embodiment, a content of the silicone
lubricant grafted with the acryl group is equal to or more than
0.5 parts by mass per 100 parts by mass of the base polymer. As
a result, the lubrication of the chlorine-based rubber composite
25 can be more reliably improved. As a result, the abrasion
resistance of the chlorine-based rubber composite can be improved.
In the present embodiment, the content of the silicone lubricant
grafted with the acryl group is equal to or less than 5 parts by
mass per 100 parts by mass of the base polymer. As a result,
30 decrease in supply stability in the electric-wire/cable extrusion
coating can be prevented. The content of the silicone lubricant
grafted with the acryl group is preferably equal to or more than

1 part by mass and equal to or less than 5 parts by mass per 100 parts by mass of the base polymer. As a result, the abrasion resistance of the chlorine-based rubber composite can be further improved.

5 <Additive>

Various additives, a range of which does not inhibit the effects of the present invention, can be additionally mixed with the chlorine-based rubber composite of the present embodiment. As such additives, organic peroxide, hydrogen chloride scavenger,
10 plasticizer, lubricant, reinforcing agent, filler, flame retardant or another additive can be mixed.

The silane can be grafted by the organic peroxide. Although not particularly limited, examples of the organic peroxide are dicumyl peroxide, 1,1-di(t-butylperoxy)cyclohexane, t-
15 butylperoxy isopropyl carbonate, t-amylperoxy isopropyl carbonate, 2,5-dimethyl-2,5-di(t-butylperoxy)hexane, di-t-butyl peroxide, di-t-amyl peroxide, 1,1-di(t-amylperoxy)cyclohexane, t-butylperoxy 2-ethylhexyl carbonate and the like. Single use of these materials or combination use of two or more thereof is
20 applicable.

The hydrogen chloride scavenger can efficiently capture the hydrogen chloride possibly generated from the chlorine-based rubber. Examples of the hydrogen chloride scavenger are epoxy group-containing compounds, hydrotalcites, lead-containing
25 compounds such as tribasic lead sulfate, tin-containing compounds, metallic soaps and the like.

Further, by addition of an antioxidant or a silanol condensation catalyst to the silane-grafted rubber composite, heat resistance can be improved, and a crosslinking reaction can
30 be promoted. The antioxidant or the silanol condensation catalyst may inhibit the silane grafting reaction, and may cause poor molding, and therefore, is preferably mixed with the silane-

grafted rubber composite at a final molding stage (in the case of the electric wire/cable, at an extrusion coating stage to a conductor or a cable core).

Particularly, examples of the silanol condensation catalyst are Group II elements such as magnesium and calcium, Group VIII elements such as cobalt and iron, elements such as tin, zinc, and titanium, metal compounds thereof, metal salts of octylic acid and adipic acid, amine-based compounds, acids and the like. More specific examples thereof are dioctyltin dineodecanoate, dibutyltin dilaurate, dibutyltin diacetate, dibutyltin dioctate, stannous acetate, stannous caprylate, lead naphthenate, zinc caprylate, cobalt naphthenate, ethylamine, dibutylamine, hexylamine, pyridine, inorganic acids such as sulfuric acid and hydrochloric acid, and organic acids such as toluenesulfonic acid, acetic acid, stearic acid, and maleic acid and the like.

The silanol condensation catalyst is preferably a tin-based compound having a high catalytic ability as well as an octyltin compound that does not contain dibutyltin considered to provide comparatively large environmental burdens. For example, the octyltin compound in a master batch state in which the octyl tin compound is mixed into a polymer is added to the chlorine-based rubber composite. In the master batch, the molecules of the silane coupling agent can be chemically bonded by the action of water.

Examples of the plasticizer are phthalate-based plasticizers such as bis(2-ethylhexyl) phthalate, diisononyl phthalate, diisodecyl phthalate and diundecyl phthalate, adipate-based plasticizers such as bis(2-ethylhexyl) adipate, diisononyl adipate, diisodecyl adipate and bis(2-butoxyethyl) adipate, polyester-based plasticizers, phosphate-based plasticizers, epoxy-based plasticizers, and trimellitate-based

plasticizers. Single use of these materials or combination use of two or more thereof is applicable.

In addition to the silicone lubricant grafted with the acryl group, for example, a lubricant based on fatty acid amide (amide), zinc stearate, silicone, a hydrocarbon-based lubricant, an ester-based lubricant, an alcohol-based lubricant, a lubricant based on a metallic soap, or the like can be added.

Examples of the reinforcing agent are carbon black, silica and the like. The reinforcing agent is preferably carbon black.

Examples of the filler are diatomite, calcined diatomite, quartz, cristobalite, kaolinite, kaolin clay, calcined clay, talc, muscovite, wollastonite, serpentine, pyrophyllite, calcium carbonate, barium sulfate, titanium oxide, magnesium carbonate, dolomite, and aluminum oxide.

Examples of the flame retardant are metal hydroxides and halogen-based, phosphorus-based, and antimony-based flame retardants.

<Method of Manufacturing Chlorine-Based Rubber Composite>

Examples of a method of kneading and manufacturing the chlorine-based rubber composite, and a method of manufacturing the electric wire or the cable using the chlorine-based rubber composite are described below. The conditions for mixing and kneading the composite materials, and the conditions for manufacturing the electric wire or the cable are not limited to the following conditions at all.

The method of manufacturing the chlorine-based rubber composite according to the present embodiment includes, for example, kneading of the silane coupling agent and various additives with the mixed base polymer made of the ethylene-vinyl acetate copolymer and the chlorinated polyethylene which is the chlorine-based rubber, the silane graft process, and the crosslinking process.

An apparatus for achieving the kneading and the graft process described above is not particularly limited to the kneader as long as the apparatus is a commonly-used kneading/reacting apparatus such as a roller, an extruder, a mixer, and an autoclave. The conditions for the kneading and the graft process are not limited to the above, either.

<Electric Wire>

Next, the electric wire according to the present embodiment will be described. The electric wire 10 according to the present embodiment includes: a conductor 9; and an insulation layer 11 that coats and protects the conductor 9. As the electric wire, the electric wire 10 in which the outer periphery of the conductor 9 is coated with the insulation layer 11 as illustrated in FIG. 1 is exemplified. The insulation layer 11 is preferably made of the chlorine-based rubber composite described above. As a result, the tackiness (adhesiveness) of the surface of the electric wire 10 can be decreased.

The conductor 9 may be a generally-used metal wire, and, for example, a copper wire, a copper alloy wire, an aluminum wire, a gold wire, a silver wire, or the like can be used. Alternatively, as the conductor 9, a metallic wire, a periphery of which is plated with a metal such as nickel, can be used. Still alternatively, as the conductor 9, an intertwined conductor formed by intertwining metallic wires can be also used.

As an example of the extruder that manufactures the electric wire according to the present embodiment, FIG. 2 is a view illustrating the schematic configuration of the extruder. As illustrated in FIG. 2, an extruder 1 includes: a cylinder 5; a screw 3 that is pivotably disposed in the cylinder 5; a hopper 2 that supplies the material into the cylinder 5; and a cross head 7. Moreover, the extruder 1 includes a neck 6 between the cross head 7 and the screw 3. Further, the extruder 1 includes

a breaker plate 4 between the neck 6 and the screw 3. The cross head 7 includes a die 8. The conductor 9 that passes through the cross head 7 is coated with an insulation layer in the cross head 7, and passes through the die 8, and is drawn out as the electric wire 10 from inside of the cross head 7.

<Cable>

FIG. 1 illustrates a cross-sectional view of the cable according to one embodiment of the present invention. As illustrated in FIG. 1, a cable 13 includes: conductors 9, insulation layers 11, and a coating layer 12. The cable 13 includes three electric wires 10. The three electric wires 10 are intertwined.

The same material as the material of the conductor 9 of the electric wire 10 described above can be used for the conductor 9. The same material as the material of the insulation layer 11 of the electric wire 10 described above can be used for the insulation layer 11.

The insulation layer 11 may be made of an insulation material that is commonly used in the cable, and is not particularly limited. Examples of the insulation material of the insulation layer 11 are ethylene-propylene copolymer admixture, polyvinyl chloride, fluorine resin, crosslinked polyethylene, natural rubber, synthetic rubber and the like.

The coating layer 12 is preferably made of the chlorine-based rubber composite described in the present embodiment described above. As a result, the tackiness (adhesiveness) of the surface of the cable 13 can be decreased. In the method of manufacturing the cable 13, the cable 13 can be manufactured by coating the outer peripheries of the insulation layers 11 formed on the conductors 9 with the chlorine-based rubber composite described above under use of the extruder.

The cable 13 according to the present embodiment can be

manufactured under the use of the extruder 1 that manufactures the electric wire 10. The cable 13 including the coating layer 12 made of the chlorine-based rubber composite can be manufactured under the use of the extruder 1 by a method similar
5 to the method of manufacturing the electric wire 10 described above in replace of the conductor 9 with the electric wire 10.

The cable 13 manufactured as described above is, for example, the cable 13 having the configuration illustrated in FIG. 1. Particularly, a multicore cable preferably includes an
10 electric wire having a conductor cross-sectional area size of about 38 mm² in conformity with the Electrical Appliances and Materials Safety Act (Appended Table 1) or JIS C3327.

Working Examples

Each of the following embodiments is an example of
15 manufacture of the electric wire or the cable under application of the chlorine-based rubber composite according to the present invention to the electric wire insulator or the sheath of the cable for understanding the present invention. The conductor type and structure, the inclusion, the semiconductive layer, the
20 binding tape, a shield braid, and the structure and application of the electric wire/cable to which the reinforcing layer is applied are not limited at all.

(Kneading of Silane Coupling Agent and Various Additives)

The chlorinated polyethylene, the ethylene-vinyl acetate
25 copolymer, the silane coupling agent, the organic peroxide, the hydrogen chloride scavenger, the plasticizer, the lubricant, the reinforcing agent, the filler, and the flame retardant were introduced into a pressure kneader having a capacity of 25 L (in which a temperature of a kneader tank was adjusted to 100°C),
30 and were pressurized and kneaded at a rotor rotation speed of 10 rpm for 10 minutes. The dispersibility of the organic peroxide in the polymer can be improved by previously dissolving the

organic peroxide in the silane coupling agent. The adsorption of the silane coupling agent onto the kneader tank can be reduced by permeating the silane coupling agent (in which the organic peroxide is dissolved) into the filler such as the reinforcing agent with in the introduction. A viscosity of the materials in kneading of the additives can be increased to improve the dispersibility of the additives by introducing the ethylene-vinyl acetate copolymer at the end of the kneading. These conditions are merely exemplified, and are not limited.

10 (Silane Graft Process)

After the kneading described above, the materials were heated until its temperature reaches 180°C while being kneaded at a rotor rotation speed of 30 rpm under the use of the same apparatus (the pressure kneader having the capacity of 25 L, in which the temperature of the kneader tank was adjusted to 100°C). This operation can be continuously performed without discharging the materials after the kneading described above. After the temperature reached 180°C, the rotation speed is decreased, and isothermal kneading was performed for 3 minutes and 30 seconds to dynamically graft the silane coupling agent to the polymer. After the completion of the graft, the materials were immediately discharged to a single-screw extruder hopper, were extruded in strand form, were cooled by water, and then, were pelletized to manufacture the pellets of the silane-grafted composite. In this case, a granulation method is not limited to the above. For example, the pellets may be manufactured under use of a hot cut facility without the water-cooling. A mold release agent can be used to prevent adhesion between the pellets. As the mold release agent, its component and form such as powdery form, liquid form, or mist form are not limited. However, for example, talc or the like is effectively used in consideration of economic efficiency.

(Kneading of Silanol Condensation Catalyst Master Batch)

The polymer (the hydrogen chloride scavenger can be used in the case with the chlorine-based rubber), the antioxidant, and the silanol condensation catalyst were introduced to the same pressure kneader having the capacity of 25 L as described above
5 (in which the temperature of the kneader tank was adjusted to 100°C), and were pressured and kneaded at a rotation speed of 10 rpm for 10 minutes. As the polymer, the same chlorinated polyethylene and ethylene-vinyl acetate copolymer as the main materials may be used, but not particularly limited. The kneaded
10 materials were granulated into the pellet form as similar to the silane graft process described above, and the mold release agent may be used to prevent the adhesion between the pellets.

(Manufacturing and Crosslinking Process of Cable)

A manufacturing and crosslinking process of the cable using
15 the manufactured compound was further performed as described below.

The cable (having a finished outer diameter of about 31 mm) was manufactured by the extrusion coating of the master-batch pellet and silane-grafted composite dry-blended at a
20 blending ratio of Table 1 to have a thickness of 3.0 mm on the cable core formed by intertwining three core wires under use of the single-screw extruder having a screw diameter of 90 mm, the core wire being formed by the extrusion coating and the crosslinking of the ethylene-propylene rubber copolymer
25 admixture as the insulator having a thickness of 1.2 mm on the conductor having a conductor cross-sectional area of 38 mm² (outside diameter of 9.1 mm) formed by intertwining a plurality of tin-plated soft copper wires. The manufactured cable was stored at 60°C for 24 hours under saturated vapor atmosphere to
30 be crosslinked.

An apparatus for achieving the kneading and the graft process described above is not particularly limited to the

kneader as long as the apparatus is a commonly-used kneading/reacting apparatus such as a roller, an extruder, a mixer, and an autoclave. The conditions for the kneading and the graft process are not limited to the above, either. Similarly, 5 the cable manufacturing is merely exemplified. The extruder, the cable core, the cable structure and the conditions for the crosslinking are not limited to the above at all.

More specifically, the silane-grafted composite, the master batch, and the cable were manufactured based on the 10 facility, the cable structure, the extrusion conditions for manufacturing the cable, and the material mixture illustrated in FIGs. 1 and 2 and Tables 1 and 2. The properties of the crosslinked were evaluated as described below.

Table 1

EACH UNIT OF BASE POLYMER TO CROSS-LINKING CATALYST IS PARTS BY MASS										
CATEGORY	ITEM	PRODUCT NAME OR OTHERS	COMPARATIVE EXAMPLE 1	COMPARATIVE EXAMPLE 2	WORKING EXAMPLE 1	WORKING EXAMPLE 2	WORKING EXAMPLE 3	WORKING EXAMPLE 4	COMPARATIVE EXAMPLE 3	
BASE POLYMER	CHLORINATED POLYETHYLENE	ELASLEN 252B *1	70	70	70	70	70	70	70	
	ETHYLENE-VINYL ACETATE COPOLYMER	VF-120T *2	30	30	30	30	30	30	30	
CROSS LINKER	SILANE COUPLING AGENT	KBM-503 *3	5	5	5	5	5	5	5	
	ORGANIC PEROXIDE	DGP *4	0.3	0.3	0.3	0.3	0.3	0.3	0.3	
ADDITIVE	HYDROGEN CHLORIDE SCAVENGER	HYDROTALCITE	2	2	2	2	2	2	2	
		EPOXY COMPOUND	0.7	0.7	0.7	0.7	0.7	0.7	0.7	
	PLASTICIZER	PHTHALATES	4	4	4	4	4	4	4	
		SILICON ACRYL-BASED COMPOUND *5		0.1	0.5	1	2.5	5	7.5	
	REINFORCING AGENT	CARBON BLACK *6	30	30	30	30	30	30	30	
	FILLER	TALC	15	15	15	15	15	15	15	
MASTER BATCH	FLAME RETARDANT	ANTIMONY TRIOXIDE	3	3	3	3	3	3	3	
		MATERIALS BELOW	3	3	3	3	3	3	3	
<MASTER BATCH CONTENT>										
POLYMER	SAME AS BASE POLYMER ABOVE									
	SAME AS HYDROGEN CHLORIDE SCAVENGER ABOVE									
ADDITIVE	ANTIOXIDANT	AMINE-BASED ANTIOXIDANT	4	4	4	4	4	4	4	
	SILANOL CONDENSATION CATALYST	OCTYL TIN COMPOUND	8	8	8	8	8	8	8	
EVALUATION	ADHESION BETWEEN MATERIALS	STATIC FRICTION COEFFICIENT VALUE IN PARENTHESES INDICATES DECREASE PERCENTAGE (%) COMPARED TO COMPARATIVE EXAMPLE 1	0.213 x (0)	0.209 x (1.9)	0.202 O (5.2)	0.197 O (7.5)	0.187 ◎ (12.2)	0.107 ◎ (49.8)	0.091 ◎ (57.3)	
	ABRASION RESISTANCE	ABRASION DEPTH (mm) VALUE IN PARENTHESES INDICATES DECREASE PERCENTAGE (%) COMPARED TO COMPARATIVE EXAMPLE 1	2.80 x (0)	2.77 x (1.1)	2.72 O (2.9)	2.67 O (4.6)	2.57 O (8.2)	2.04 ◎ (27.1)	1.90 ◎ (32.1)	
	CABLE EXTRUSION WORKABILITY	MATERIAL SUPPLY STABILITY	O (GOOD) FAIL	O (GOOD) FAIL	O (GOOD) PASS	O (GOOD) PASS	O (GOOD) PASS	O (GOOD) PASS	x (UNSTABLE) FAIL	

*1: produced by Resonac corporation, *2: produced by Dow-

Mitsui Polychemicals Co., Ltd., *3: produced by Shin-Etsu Chemical Co., Ltd., *4: produced by NOF corporation, *5: Chaline R-175S produced by Nissin Chemical Industry Co., Ltd., *6: HTC#S (arithmetic mean particle diameter: 68nm) produced by NIPPON STEEL Chemical & Material Co., Ltd.

Table 2

TABLE 2

ITEM		SETTING
EXTRUDER	SIZE	90-mm SINGLE SCREW
TEMPERATURE (°C)	CYLINDER 1	110
	CYLINDER 2	135
	CYLINDER 3	135
	CYLINDER 4	140
	CYLINDER 5	140
	FLANGE	150
	NECK	160
	HEAD	160
	DIE	160
SCREW	ROTATION SPEED (rpm)	20

(1) Adhesiveness (Static Friction Coefficient) between Sheath Materials

10 A strip test piece "a14" having a thickness of 1 mm, a length of 100 mm, and a width of 15 mm, and a test piece "b15" having a thickness of 1 mm, a length of 10 mm, and a width of 10 mm were manufactured by peeling off the crosslinked cable sheath and grinding the cable from an inner side (closer to the

15 insulator). As illustrated in FIG. 3, the test piece b15 was pasted by a double-faced tape onto an SUS plate 16 (having a weight of 0.066 N) having one end connected to a push-pull gauge 18 to bring the test piece b15 and an upper surface of the test piece a14 into contact with each other. A lower surface of the

20 test piece a14 was pasted by a double-faced tape onto a flat surface of an operation mat. A weight 17 (having a weight of 2

N) was put on the SUS plate 16, and the push-pull gauge 18 was moved to be distant by 50 mm or larger at a speed of about 500 mm/min while being prevented from vibration. The static friction coefficient was calculated from the following equation by measurement of the maximum stress (= static friction force) at which the SUS plate 16 started moving.

A rubber composite sheath not containing the silicone lubricant grafted with the acrylic group was used as a comparison object. A sample, a decrease percentage of the static friction coefficient of which from a static friction coefficient of the rubber composite sheath was lower than 5%, was evaluated as a sample having the insufficient adhesiveness decrease effect (with a mark "X" in Table 1), a sample, the decrease percentage of the static friction coefficient of which therefrom was equal to or higher than 5% and lower than 10%, was evaluated as a sample having the adhesiveness decrease effect (with a mark "O" in Table 1), and a sample, the decrease percentage of the static friction coefficient of which therefrom was equal to or higher than 10%, was evaluated as a sample having the excellent adhesiveness decrease effect (with a mark "◎" in Table 1). The samples with "O" and "◎" were evaluated as "Pass".

Static Friction Coefficient = "Static Friction Force [N] / 2.066 [N]"

Decrease Percentage [%] of Static Friction Coefficient = $\{(\mu_0 - \mu_1) / \mu_0\} \times 100$

μ_0 : Static Friction Coefficient of Comparison Object Sheath

μ_1 : Static Friction Coefficient of Interest Sheath

(2) Abrasion Resistance (Abrasion Volume of Grindstone)

The crosslinked cable was measured by a method in conformity with JIS C3005. A mass of a weight was set to 5 kg, and a rotation speed of a grindstone disk was set to 750 rounds. For the evaluation, a depth of an abraded portion in the cable

sheath subjected to the abrasion test was calculated from the following equation under use of a micrometer gauge. The rubber composite sheath not containing the silicone lubricant grafted with the acrylic group was used as the comparison object. A sample, a decrease percentage of the abrasion depth of which from an abrasion depth of the rubber composite sheath was lower than 2%, was evaluated as a sample having the insufficient decrease effect (with a mark "X" in Table 1), a sample, the decrease percentage of the static friction coefficient of which therefrom was equal to or higher than 2% and lower than 10%, was evaluated as a sample having the decrease effect (with a mark "O" in Table 1), and a sample, the decrease percentage of the static friction coefficient of which therefrom was equal to or higher than 10%, was evaluated as a sample having the excellent decrease effect (with a mark "◎" in Table 1). The samples with "O" and "◎" were evaluated as "Pass".

Abrasion depth [mm] = "Outer Diameter [mm] of Cable before Test" - "Cable Thickness [mm] of Abraded Portion after Test"

Decrease Percentage [%] of Abrasion Depth = " $\{(x_0 - x_1)/x_0\} \times 100$ "

x_0 : Abrasion Depth of Comparison Object Sheath

x_1 : Abrasion Depth of Interest Sheath

(3) Cable Extrusion Workability (Material Supply Stability)

The stability of the supply of the dry-blended master-batch pellet and silane-grafted composite from the hopper into the extruder was evaluated. A sample in which the pellet filled in the hopper was automatically transported by a screw was evaluated as "Good" (with a mark "O" in Table 1), and a sample in which the amount of the pellet transported by the screw was unstable and was difficult to be automatically supplied since the pellet was blocked in the hopper or since wedging of the pellet into

the screw was insufficient due to excessive lubrication or the like was evaluated as "Fail" (with a mark "X" in Table 1). The sample with "O" was evaluated as "Pass", and the sample with "X" was evaluated as "Fail".

5 (4) Overall Evaluation

In the tests (1) to (2) described above, a sample (with a mark "O" or "◎" in Table 1) passed in terms of both the decrease percentages compared to the comparison object was evaluated as "Pass", and a sample (with a mark "X" in Table 1) evaluated to
10 be insufficient in even either one was evaluated as "Fail".

The working examples reveal that the static friction coefficient and the abrasion depth are decreased by the addition of the silicone lubricant grafted with the acrylic group. Moreover, the working examples also reveal that the static
15 friction coefficient can be excellently decreased when the addition amount of the silicone lubricant grafted with the acrylic group is 2.5 parts by mass, and further reveal that the excellent decrease effect for the abrasion depth was exhibited when the addition amount is 5 parts by mass. Moreover, it has
20 been confirmed that the pellet can be stably automatically supplied at the time of the cable extrusion under the conditions of all the working examples.

The comparative example 2 reveals that the small addition amount of the silicone lubricant grafted with the acrylic group
25 results in the insufficient decreases in both the static friction coefficient and the abrasion depth. The comparative example 3 reveals that the excessive addition amount of the silicone lubricant grafted with the acrylic group results in the worse wedging into the screw because of too high lubrication of the
30 pellet surface, resulted in the difficulty in the automatic stable supply.

From the above, it has been found that the addition amount

of the silicone lubricant grafted with the acrylic group needs to be within a range from 0.5 parts by mass to 5 parts by mass for achieving both the cable extrusion workability and the decrease effects for the static friction coefficient and the abrasion depth.

According to the present invention, the addition of the silicone-acryl based lubricant to the chlorine-based rubber composite enables the decrease in the coefficient of the friction between the composites and the improvement in the abrasion resistance. Furthermore, the optimized addition amount thereof enables both the suppression in the excessive lubrication on the surface and the extrusion workability of the electric wire/cable. As a result, it is considerable that the present invention can contribute to development to applications considerably requiring the abrasion resistance and the improvement in the mutual adhesiveness particularly problematic in the electric wire/cable coated with rubber.

The present invention has been described with reference to the embodiments and working examples described above. However, the present invention is not limited to the foregoing embodiments and working examples, and various modifications can be made within the scope of the present invention.

What is claimed is:

1. A chlorine-based rubber composite comprising:

a base polymer containing a chlorine-based rubber; and
a silicone lubricant grafted with an acryl group,

5 wherein a content of the silicone lubricant is equal to or more than 0.5 parts by mass and equal to or less than 5 parts by mass per 100 parts by mass of the base polymer.

2. The chlorine-based rubber composite according to claim 1,

10 wherein the chlorine-based rubber is a chlorinated polyethylene.

3. The chlorine-based rubber composite according to claim 1,

15 wherein the base polymer further contains an ethylene-vinyl acetate copolymer.

4. The chlorine-based rubber composite according to claim 1,

wherein the base polymer is graft-polymerized by a silane coupling agent.

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5. The chlorine-based rubber composite according to claim 4, further comprising:

a hydrogen chloride scavenger;

a plasticizer; and

25 a carbon black.

6. The chlorine-based rubber composite according to claim 4,

wherein the silane coupling agent includes a methacryl group as an organic functional group.

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7. The chlorine-based rubber composite according to claim 4, further comprising:

a master batch in which an octyl tin compound as a silanol condensation catalyst is mixed into a polymer,

wherein the master batch makes a chemical bond among molecules of the silane coupling agent by using action of water.

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8. An electric wire comprising:

a conductor; and

an insulation layer coating an outer periphery of the conductor,

10 wherein the insulation layer is made of the chlorine-based rubber composite according to claim 1.

9. A cable comprising:

a conductor;

15 an insulation layer coating an outer periphery of the conductor; and

a coating layer coating a periphery of the insulation layer,

wherein the coating layer is made of the chlorine-based rubber composite according to claim 1.

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