

DESCRIPTION

METALLIC MATERIAL HAVING CHROMATE-FREE-TREATED SURFACE
EXCELLENT IN CORROSION RESISTANCE, HEAT RESISTANCE, ANTI-
5 FINGERPRINT PROPERTY, CONDUCTIVITY, COATING PROPERTY AND
BLACK DEPOSIT RESISTANCE DURING PROCESSING

TECHNICAL FIELD

The present invention relates to a chromate-free
10 surface treated metal material with excellent corrosion
resistance, heat resistance, fingermark resistance,
conductivity, coatability, and blackening resistance at
the time of working.

BACKGROUND ART

15 In general, as technologies for giving a coating
excellent in adhesion to the surface of a metal material
and imparting corrosion resistance, fingermark
resistance, etc. to the surface of a metal material, a
method of chromate treatment of the surface of a metal
20 material by a treatment solution containing chromic acid,
dichromic acid, or a salt thereof as main ingredients, a
method of treating it by a phosphate, a method of
treating it by a silane coupling agent alone, a method of
treating it by an organic resin coating, etc. have been
25 known and put into use.

As technology mainly using inorganic ingredients, JP
2002-30460 A describes a metal surface treatment agent
containing a vanadium compound and a metal compound
including at least one metal selected from zirconium,
30 titanium, molybdenum, tungsten, manganese, and cerium.

On the other hand, as technology using mainly a
silane coupling agent, US 5,292,549 teaches treatment of
a metal sheet by an aqueous solution containing a low
concentration of an organic functional silane and cross-
35 linking agent for obtaining a temporary corrosion
proofing effect. This discloses a method of having the
cross-linking agent cross-link the organic functional

silane so as to form a dense siloxane film.

Further, JP 2003-105562 A discloses a nonchromate surface treated steel sheet excellent in corrosion resistance and excellent in fingermark resistance, blackening resistance, and coating adhesion obtained using a surface treatment agent containing a specific resin compound (A), cationic urethane resin (B) having at least one type of cationic functional group selected from primary to tertiary amino groups and a quaternary ammonium salt group, at least one type of silane coupling agent (C) having a specific reactive functional group, and a specific acid compound (E) and having contents of the cationic urethane resin (B) and silane coupling agent (C) in predetermined ranges and a method of production of the same.

However, these technologies do not satisfy all of the requirements of corrosion resistance, heat resistance, fingermark resistance, conductivity, and blackening resistance at the time of working and continue to have problems for practical application.

In this way, at the present time, none of these methods can give a surface treatment agent able to be used to replace a chromate film. Development of a surface treatment agent and method of treatment able to comprehensively satisfy these is being strongly demanded.

DISCLOSURE OF THE INVENTION

The present invention has as its object to solve the above problem in the prior art and provide a metal material given a chromate-free surface treatment satisfying all of the requirements of corrosion resistance, heat resistance, fingermark resistance, conductivity, coatability, and blackening resistance at the time of working.

The inventors engaged in repeated intensive studies to solve this problem and as a result discovered that by coating and drying on the surface of a metal material an aqueous metal surface treatment agent comprising an

organic silicon compound (W), obtained by blending two types of specific silane coupling agents in a specific solid weight ratio and containing at least two specific functional groups in its molecule and containing at least one specific hydrophilic functional group, a fluorocompound (X), phosphoric acid (Y), and a vanadium compound (Z) so as to form a composite coating containing the different ingredients, it is possible to obtain a chromate-free surface treated metal material satisfying all of the requirements of corrosion resistance, heat resistance, fingerprint resistance, conductivity, coatability, and blackening resistance at the time of working and thereby completed the present invention.

That is, the present invention relates to a surface treated metal material, characterized by being comprised of a metal material on the surface of which is coated and dried an aqueous metal surface treatment agent comprising an organic silicon compound (W), obtained by blending a silane coupling agent (A) containing one amino group in its molecule and a silane coupling agent (B) containing one glycidyl group in its molecule in a solid weight ratio [(A)/(B)] of 0.5 to 1.7 and containing, in its molecule, at least two functional groups (a) represented by the formula $-\text{SiR}^1\text{R}^2\text{R}^3$ (wherein, R^1 , R^2 , and R^3 independently represent an alkoxy group or hydroxy group, at least one representing an alkoxy group) and one or more of at least one type of hydrophilic functional group (b) selected from hydroxy group (one separate from that able to be included in the functional group (a)) and an amino group, and having an average molecular weight of 1000 to 10000, at least one type of fluorocompound (X) selected from fluorotitanic acid or fluorozirconic acid, phosphoric acid (Y), and a vanadium compound (Z) so as to form a composite coating containing the different ingredients, and among the ingredients of the composite coating, the solid weight ratio [(X)/(W)] of the organic silicon compound (W) and fluorocompound (X) being 0.02 to

0.07, the solid weight ratio $[(Y)/(W)]$ of the organic silicon compound (W) and phosphoric acid (Y) being 0.03 to 0.12, the solid weight ratio $[(Z)/(W)]$ of the organic silicon compound (W) and vanadium compound (Z) being 0.05 to 0.17, and the solid weight ratio $[(Z)/(X)]$ of the fluorocompound (X) and vanadium compound (Z) being 1.3 to 6.0.

Preferably, the aqueous metal surface treatment agent further contains, as an ingredient (C), in the coating, at least one type of cobalt compound selected from the group comprised of cobalt sulfate, cobalt nitrate, and cobalt carbonate, where the solid weight ratio $[(C)/(W)]$ of the organic silicon compound (W) and cobalt compound (C) is 0.01 to 0.1.

Preferably, the above surface treated metal material is comprised of a metal material on the surface of which the aqueous metal surface treatment agent is coated and dried at a peak temperature higher than 50°C and less than 250°C to give a dried coating weight of 0.05 to 2.0 g/m².

The metal material is preferably a zinc-based plated steel sheet.

The surface treated metal material of the present invention satisfies all of the requirements of the corrosion resistance, heat resistance, fingermark resistance, conductivity, coatability, and blackening resistance at the time of working.

BEST MODE FOR CARRYING OUT THE INVENTION

The metal materials able to be used in the present invention are not particularly limited, and may include, for example, iron, an iron-based alloy, aluminum, an aluminum-based alloy, copper, a copper-based alloy, etc. A plated metal material comprised of any of these metal materials which are then plated can also be used. Among these, the most preferable in applications of the present invention is a zinc-based plated steel sheet. The zinc-based plated steel sheets include those such as zinc-plated steel sheets, zinc-nickel plated steel sheets,

zinc-iron plated steel sheets, zinc-chrome plated steel sheets, zinc-aluminum plated steel sheets, zinc-titanium plated steel sheets, zinc-magnesium plated steel sheets, zinc-manganese plated steel sheets, zinc-aluminum-
5 magnesium plated steel sheets, and zinc-aluminum-magnesium-silicon plated steel sheets, and other zinc-based plated steel sheets with these plating layers further containing small amounts of different metal elements or impurities such as cobalt, molybdenum,
10 tungsten, nickel, titanium, chrome, aluminum, manganese, iron, magnesium, lead, bismuth, antimony, tin, copper, cadmium, arsenic, etc. or having silica, alumina, titania, or other inorganic matter dispersed. Further, the above plating and another type of plating, for
15 example iron plating, iron-phosphorus plating, nickel plating, or cobalt plating, may be combined to obtain double-layer plating. The plating method is not particularly limited, but a known electroplating method, hot dip plating, vapor deposition plating method,
20 dispersion plating method, vacuum plating method or the like may be used.

The essential ingredient organic silicon compound (W) of the aqueous metal surface treatment agent for a chromate-free surface treated metal material of the
25 present invention is obtained by blending a silane coupling agent (A) containing one amino group in the molecule and a silane coupling agent (B) containing one glycidyl group in the molecule in a solid weight ratio $[(A)/(B)]$ of 0.5 to 1.7. The silane coupling agent (A)
30 and the silane coupling agent (B) are needed to be blended in a solid weight ratio $[(A)/(B)]$ of 0.5 to 1.7, preferably 0.7 to 1.7, and most preferably 0.9 to 1.1. If the solid weight ratio $[(A)/(B)]$ is less than 0.5, the fingerprint resistance, bath stability, and blackening
35 resistance remarkably fall, so this is not preferable. Conversely, if over 1.7, the waterproofness remarkably falls, so this is not preferable.

Further, the silane coupling agent (A) containing one amino group in the molecule in the present invention is not particularly limited, but, 3-aminopropyltriethoxysilane, 3-aminopropyltrimethoxysilane, etc. may be illustrated. As the silane coupling agent (B) containing one glycidyl group in the molecule, 3-glycidoxypropyltrimethoxysilane, 3-glycidoxypropyltriethoxysilane, etc. may be illustrated.

Further, the method of production of the organic silicon compound (W) of the present invention is not particularly limited, but a method of successively adding the silane coupling agent (A) and the silane coupling agent (B) to water adjusted to a pH 4 and stirring for a predetermined time may be mentioned.

The number of the functional groups (a) in the essential ingredient organic silicon compound (W) of the present invention has to be two or more. If the number of functional groups (a) is 1, the bonding force to the surface of a metal material and the film-formability fall, so the blackening resistance falls. The number of carbon atoms in the alkoxy group in the definitions of R^1 , R^2 , and R^3 of the functional group (a) is not particularly limited, but 1 to 6 is preferable, 1 to 4 is more preferable, and 1 or 2 is most preferable. It is sufficient that at least one functional group (b) is present in a molecule. The organic silicon compound (W) has to have an average molecular weight of 1000 to 10000, with 1300 to 6000 being preferable. The molecular weight referred to here is not particularly limited, but either one obtained by direct measurement by a TOF-MS method or one obtained by conversion and measurement by a chromatography method may be applicable. If the average molecular weight is less than 1000, the coating formed remarkably falls in waterproofness. On the other hand, if the average molecular weight is larger than 10000, it becomes difficult to stably dissolve or disperse the organic silicon compound.

Further, regarding the amount blended of the essential ingredient fluorocompound (X) of the present invention, the solid weight ratio $[(X)/(W)]$ of the organic silicon compound (W) and fluorocompound (X) has to be 0.02 to 0.07, preferably 0.03 to 0.06, and most preferably 0.04 to 0.05. If the solid weight ratio $[(X)/(W)]$ of the organic silicon compound (W) and fluorocompound (X) is less than 0.02, the effect of addition is not manifested, so this is not preferable. Conversely, if larger than 0.07, the conductivity falls, so this is not preferable.

Further, regarding the amount blended of the essential ingredient phosphoric acid (Y) of the present invention, the solid weight ratio $[(Y)/(W)]$ of the organic silicon compound (W) and phosphoric acid (Y) has to be 0.03 to 0.12, preferably 0.05 to 0.12, and most preferably 0.09 to 0.1. If the solid weight ratio $[(Y)/(W)]$ of the organic silicon compound (W) and phosphoric acid (Y) is less than 0.03, the effect of addition is not manifested, so this is not preferable. Conversely, if over 0.12, the coating becomes remarkably water soluble, so this is not preferable.

Further, regarding the amount blended of the essential ingredient vanadium compound (Z) of the present invention, the solid weight ratio $[(Z)/(W)]$ of the organic silicon compound (W) and vanadium compound has to be 0.05 to 0.17, preferably 0.07 to 0.15, more preferably 0.09 to 0.14, and most preferably 0.11 to 0.13. If the solid weight ratio $[(Z)/(W)]$ of the organic silicon compound (W) and vanadium compound is less than 0.05, the effect of addition is not manifested, so this is not preferable. Conversely, if over 0.17, the stability drops sharply, so this is not preferable.

Further, the vanadium compound (Z) in the present invention is not particularly limited, but vanadium pentaoxide V_2O_5 , metavanadic acid HVO_3 , ammonium metavanadate, sodium metavanadate, vanadium

oxytrichloride VOCl_3 , vanadium trioxide V_2O_3 , vanadium
dioxide VO_2 , vanadium oxysulfate VOSO_4 , vanadium
oxyacetylacetonate $\text{VO}(\text{OC}(=\text{CH}_2)\text{CH}_2\text{COCH}_3)_2$, vanadium
acetylacetonate $\text{V}(\text{OC}(=\text{CH}_2)\text{CH}_2\text{COCH}_3)_3$, vanadium trichloride
5 VCl_3 , phosphorus vanadomolybdic acid, etc. may be
mentioned. Further, a vanadium compound obtained by
reducing a pentavalent compound to a tetravalent to
bivalent compound by an organic compound having at least
one type of functional group selected from the group
10 comprised of hydroxy group, carbonyl group, carboxyl
group, primary to tertiary amino group, amide group,
phosphoric acid group, and phosphonic acid group may be
used.

Further, regarding the amounts blended of the
15 essential ingredients of the present invention, that is,
the fluorocompound (X) and vanadium compound (Z), the
solid weight ratio $[(Z)/(X)]$ of the fluorocompound (X)
and vanadium compound (Z) has to be 1.3 to 6.0,
preferably 1.3 to 3.5, more preferably 2.5 to 3.3, and
20 most preferably 2.8 to 3.0. If the solid weight ratio
 $[(Z)/(X)]$ of the fluorocompound (X) and vanadium compound
(Z) is less than 1.3, the effect of addition of the
vanadium compound (Z) is not manifested, so this is not
preferable. Conversely, if over 6.0, the bath stability
25 and blackening resistance falls, so this is not
preferable.

The additional ingredient in the present invention,
that is, the cobalt compound (C), has to be at least one
type of cobalt compound selected from the group comprised
30 of cobalt sulfate, cobalt nitrate, and cobalt carbonate.
Further, the ratio blended has to be a solid weight ratio
 $[(C)/(W)]$ of the organic silicon compound (W) and cobalt
compound (C) of 0.01 to 0.1, preferably 0.02 to 0.07, and
most preferably 0.03 to 0.05. If the solid weight ratio
35 $[(C)/(W)]$ of the organic silicon compound (W) and cobalt
compound (C) is less than 0.01, the effect of addition of
the cobalt compound (C) is not exhibited, so this is not

preferable. Conversely, if larger than 0.1, the corrosion resistance falls, so this is not preferable.

5 Preferably, the surface treated metal material of the present invention is coated with the aqueous metal surface treatment agent and dried at a peak temperature higher than 50°C and less than 250°C, so as to have a dried coating weight of 0.05 to 2.0 g/m². Regarding the drying temperature, a peak temperature higher than 50°C and less than 250°C is preferable, with 70°C to 150°C
10 being more preferable, and 100°C to 140°C being most preferable. If the peak temperature is 50°C or less, the solvent of the aqueous metal surface treatment agent does not completely evaporate, so this is not preferable. Conversely, if 250°C or more, part of the organic chain of
15 the coating formed by the aqueous metal surface treatment agent breaks down, so this is not preferable. Regarding the coating weight, 0.05 to 2.0 g/m² is preferable, 0.2 to 1.0 g/m² being more preferable, and 0.3 to 0.6 g/m² being most preferable. If the coating weight is less than 0.05
20 g/m², the surface of the metal material cannot be covered, so the corrosion resistance remarkably falls, so this is not preferable. Conversely, if larger than 2.0 g/m², the blackening resistance at the time of working falls, so this is not preferable.

25 For the aqueous metal surface treatment agent used in the present invention, a leveling agent or water soluble solvent for improving the coatability, a metal stabilizing agent, an etching inhibitor, a pH adjuster, etc. can be used in a range not impairing the effect of
30 the present invention. As the leveling agent, a nonionic or cationic surfactant such as polyethylene oxide or a polypropylene oxide adduct or an acetylene glycol compound etc. may be mentioned, while as a water soluble solvent, alcohols such as ethanol, isopropyl alcohol, t-butyl alcohol, and propylene glycol, Cellosolves such as
35 ethyleneglycol monobutyl ether and ethyleneglycol

monoethyl ether, esters such as ethyl acetate and butyl acetate, and ketones such as acetone, methyl ethyl ketone, methyl isobutyl ketone, may be mentioned. As the metal stabilizing agent, EDTA, DTPA, or other chelating compounds may be mentioned. As the etching inhibitor, ethylene diamine, triethylene pentamine, guanidine, pyrimidine, and other amine compounds may be mentioned. In particular, compounds having two or more amino groups in the molecule are effective as metal stabilizing agents and are more preferable. As the pH adjuster, acetic acid, lactic acid, or other organic acids, fluoric acid or other inorganic acids, ammonium salts, amines, etc. may be mentioned.

The surface treated metal material of the present invention satisfies all of the requirements of corrosion resistance, heat resistance, fingermark resistance, conductivity, coatability, and blackening resistance at the time of working. The reason is believed to be as follows, but the present invention is not bound by this belief. The coating formed using the aqueous metal surface treatment agent used in the present invention is mainly based on organic silicon compounds. First, the corrosion resistance is believed to be due to the remarkable barrier effect exhibited by the organic silicon compounds partially reacting with each other, when the organic silicon compounds are condensed due to drying etc., to form a continuous coating, and due to part of the organic silicon compounds hydrolyzing to form -Si-OH groups which form Si-O-M bonds (M: metal element of coated surface) with the metal surface. Further, a dense coating can be formed, so the coating can be made thinner and the conductivity also becomes better.

On the other hand, using the aqueous metal surface treatment agent of the present invention, a coating is formed based on silicon. Regarding its structure, the silicon-organic chains are regularly arrayed. Further, the organic chains are relatively short. Therefore, in

extremely small sections in the coating, silicon-containing parts and organic parts, that is, inorganic matter and organic matter, are regularly and densely arrayed. Therefore, it is believed that a novel coating having both the heat resistance, conductivity, and blackening resistance during working normally possessed by an inorganic coating and the fingermark resistance, coatability and the like normally possessed by an organic coating can be formed. Note that in the silicon containing part in the coating, it was confirmed by analysis that about 80% of the silicon forms siloxane bonds.

By adding to such a base coating, for the purpose of imparting corrosion resistance, a fluorocompound for forming a dense coating by raising the pH very near the treated metal surface resulting from the etching reaction, phosphoric acid as an elution inhibitor, and a vanadium compound imparting corrosion resistance by an oxidation reduction reaction, it is believed that in addition to heat resistance, fingermark resistance, conductivity, coatability, and blackening resistance during working, excellent corrosion resistance is manifested.

EXAMPLES

Examples of the present invention and comparative examples will be given below to explain the present invention more specifically, but the present invention is not limited to them. The methods of preparing the test sheets, examples and comparative examples, and the methods of coating the surface treatment agent for a metal material will be explained below.

Preparation of Test Sheets

(1) Test Materials

The commercially available materials shown below were used.

Electrogalvanized steel sheet (EG): sheet thickness = 0.8 mm, amount of plating = 20/20 (g/m²)

Hot dip zincing steel sheet (GI): sheet thickness = 0.8 mm, amount of plating = 90/90 (g/m²)

Electrogalvanized-12% nickel plating (ZL): sheet thickness = 0.8 mm, amount of plating = 20/20 (g/m²)

5 Hot dip zinc-11% aluminum-3% magnesium-0.2% silicon plating (SD): sheet thickness = 0.8 mm, amount of plating = 60/60 (g/m²)

(2) Degreasing

10 The material was sprayed with a silicate based alkali degreasing agent "Fine Cleaner 4336" (registered trademark, made by Nihon Parkerizing) under conditions of a concentration of 20 g/liter and temperature of 60°C for 2 minutes, was rinsed with pure water for 30 seconds, and then dried to obtain a test sheet.

15 The silane coupling agents used for the examples and comparative examples are shown in Table 1, the vanadium compounds in Table 2, and the formulations, amounts of coating, and drying temperatures are shown in Tables 3 to 5.

20 [Evaluation Test]

1. SST Flat Part Test

A salt spray test (SST) according to JIS Z 2371 was performed for 120 hours and the state of white rusting was examined.

25 <Evaluation Criteria>

A=Rusting of less than 3% of total area

B=Rusting of 3 to less than 10% of total area

C=Rusting of 10% to less than 30% of total area

D=Rusting of 30% or more of total area

30 2. SST Worked Part Test

An Erichsen test (7 mm extrusion) was performed, then a salt spray test according to JIS Z 2371 was performed for 72 hours. The state of white rusting was examined.

35 <Evaluation Criteria>

A=Rusting of less than 10% of total area

B=Rusting of 10% to less than 20% of total area

C=Rusting of 20% to less than 30% of total area

D=Rusting of 30% or more of total area

3. Heat Resistance Test

5 An oven was used for heating a test sheet at 200°C for 2 hours, and then the flat part was tested for corrosion resistance by a salt spray test according to JIS Z 2371 for 48 hours. The state of white rusting was examined.

<Evaluation Criteria>

10 A=Rusting of less than 3% of total area

B=Rusting of 3% to less than 10% of total area

C=Rusting of 10% to less than 30% of total area

D=Rusting of 30% or more of total area

4. Fingerprint Resistance Test

15 A color difference meter was used to measure the change in L value (ΔL) before and after coating with vaseline.

<Evaluation Criteria>

A= ΔL of less than 0.5

20 B= ΔL of 0.5 to less than 1.0

C= ΔL of 1.0 to less than 2.0

D= ΔL of 2.0 or more

5. Conductivity Test

25 A surface insulation resistance measuring device was used to measure the surface insulation resistance.

<Evaluation Criteria>

A=Surface insulation resistance of less than 1.0Ω

B=Surface insulation resistance of 1.0Ω to less than 2.0Ω

C=Surface insulation resistance of 2.0Ω to less than 3.0Ω

30 D=Surface insulation resistance of less than 3.0Ω

6. Coatability Test

35 A melamine alkyd-based coating was coated by a bar coater so as to have a film thickness of 25 micrometers after baking and drying, baked at 120°C for 20 minutes, then cut into a grid of 1 mm squares. The adhesion was

evaluated by the ratio of the remaining square number
(remaining square number/cut square number: 100).

<Evaluation Criteria>

A=100%

5 B=95% or more

C=90% to less than 95%

D=less than 90%

7. Blackening Test

10 The degree of blackening in the case of working by a
drawing ratio of 2.0 in a high speed deep drawing test
was evaluated by the change in the L value before and
after the test.

A= ΔL of less than 0.5

B= ΔL of 0.5 to less than 1.0

15 C= ΔL of 1.0 to less than 2.0

D= ΔL of 2.0 or more

20 The test results are shown in Tables 6 to 17. It is
learned that Examples 1 to 68 exhibit corrosion
resistances equivalent to chromate and satisfy all of the
requirements of good corrosion resistance, heat
resistance, fingermark resistance, conductivity,
coatability, and blackening resistance at the time of
working.

Table 1

	Silane coupling agent
A1	3-aminopropyltrimethoxysilane
A2	3-aminopropyltriethoxysilane
B1	3-glycidoxypropyltrimethoxysilane
B2	3-glycidoxypropyltriethoxysilane

Table 2

	Vanadium compound
Z1	Vanadium oxysulfate
Z2	Vanadium dioxide
Z3	Vanadium oxyacetylacetonate
Z4	Vanadium acetylacetonate

Table 3

	Organic silicon compound (W)						Fluorocompound (X)		Phosphoric acid (Y)		V compound (Z)			Coating am't	Drying temperature	Co-compound (C)
	Silane coupling agent		Ratio (A)/(B)	Functional group (a) no.	Molecular weight	Fluorocompound (X)		Phosphoric acid (Y)		V compound (Z)						
						Type	Ratio (X)/(W)	Ratio (Y)/(W)	Type	Ratio						
										(Z)/(W)	(Z)/(X)					
Ex. 1	A1	B1	0.5	2	1500	Zr	0.03	0.05	Z1	0.07	2.3	0.35	120°C	-		
Ex. 2	A1	B1	0.7	2	1500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 3	A1	B1	1.0	2	1500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 4	A1	B1	1.2	2	1500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 5	A1	B1	1.5	2	1500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 6	A1	B1	1.7	2	1500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 7	A1	B2	1.0	2	1500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 8	A1	B1	1.0	3	1500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 9	A1	B1	1.0	2	1000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 10	A1	B1	1.0	2	2000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 11	A1	B1	1.0	2	4000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 12	A1	B1	1.0	2	8000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 13	A1	B1	1.0	2	10000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Ex. 14	A1	B1	1.0	2	3000	Zr	0.02	0.06	Z1	0.05	2.5	0.35	120°C	-		
Ex. 15	A1	B1	1.0	2	3000	Zr	0.05	0.06	Z1	0.12	2.4	0.35	120°C	-		
Ex. 16	A1	B1	1.0	2	3000	Zr	0.07	0.06	Z1	0.16	2.3	0.35	120°C	-		
Ex. 17	A1	B1	1.0	2	3000	Ti	0.02	0.06	Z1	0.05	2.5	0.35	120°C	-		
Ex. 18	A1	B1	1.0	2	3000	Ti	0.05	0.06	Z1	0.12	2.4	0.35	120°C	-		
Ex. 19	A1	B1	1.0	2	3000	Ti	0.07	0.06	Z1	0.16	2.3	0.35	120°C	-		
Ex. 20	A2	B1	1.0	2	3000	Ti	0.05	0.03	Z1	0.07	1.4	0.35	120°C	-		
Ex. 21	A2	B1	1.0	2	3000	Ti	0.05	0.05	Z1	0.07	1.4	0.35	120°C	-		
Ex. 22	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	0.35	120°C	-		
Ex. 23	A2	B1	1.0	2	3000	Ti	0.05	0.1	Z1	0.07	1.4	0.35	120°C	-		
Ex. 24	A2	B1	1.0	2	3000	Ti	0.05	0.12	Z1	0.07	1.4	0.35	120°C	-		
Ex. 25	A2	B2	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	0.35	120°C	-		
Ex. 26	A2	B1	1.0	2	3000	Ti	0.06	0.07	Z1	0.08	1.3	0.35	120°C	-		
Ex. 27	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.10	2.0	0.35	120°C	-		
Ex. 28	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.13	2.6	0.35	120°C	-		
Ex. 29	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.15	3.0	0.35	120°C	-		
Ex. 30	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.17	3.4	0.35	120°C	-		
Ex. 31	A2	B1	1.0	2	3000	Ti	0.03	0.07	Z1	0.15	5.0	0.35	120°C	-		
Ex. 32	A2	B1	1.0	2	3000	Ti	0.02	0.07	Z1	0.12	6.0	0.35	120°C	-		
Ex. 33	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z2	0.07	1.4	0.35	120°C	-		
Ex. 34	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z2	0.10	2.0	0.35	120°C	-		

Table 4

	Organic silicon compound (W)						Fluorocompound (X)		Phosphoric acid (Y)		V compound (Z)				Coating am't	Drying temperature	Co-compound (C)
	Silane coupling agent		Ratio (A)/(B)	Functional group (a) no.	Molecular weight	Type	Ratio (X)/(W)	Ratio (Y)/(W)	Type	Ratio		Type	(Z)/(X)				
										(Z)/(W)	(Z)/(X)						
														(A)			
Ex. 35	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z2	0.13	2.6	Z2	0.35	120°C	-		
Ex. 36	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z3	0.07	1.4	Z3	0.35	120°C	-		
Ex. 37	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z3	0.10	2.0	Z3	0.35	120°C	-		
Ex. 38	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z3	0.13	2.6	Z3	0.35	120°C	-		
Ex. 39	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z4	0.07	1.4	Z4	0.35	120°C	-		
Ex. 40	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z4	0.10	2.0	Z4	0.35	120°C	-		
Ex. 41	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z4	0.13	2.6	Z4	0.35	120°C	-		
Ex. 42	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z5	0.07	1.4	Z5	0.35	120°C	-		
Ex. 43	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z5	0.10	2.0	Z5	0.35	120°C	-		
Ex. 44	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z5	0.13	2.6	Z5	0.35	120°C	-		
Ex. 45	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.10	120°C	-		
Ex. 46	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.15	120°C	-		
Ex. 47	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.20	120°C	-		
Ex. 48	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.25	120°C	-		
Ex. 49	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.30	120°C	-		
Ex. 50	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.40	120°C	-		
Ex. 51	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.45	120°C	-		
Ex. 52	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.50	120°C	-		
Ex. 53	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.55	120°C	0.02		
Ex. 54	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.60	120°C	0.04		
Ex. 55	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	60°C	0.06		
Ex. 56	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	70°C	-		
Ex. 57	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	80°C	-		
Ex. 58	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	90°C	-		
Ex. 59	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	100°C	-		
Ex. 60	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	110°C	-		
Ex. 61	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	130°C	-		
Ex. 62	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	140°C	-		
Ex. 63	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	150°C	-		
Ex. 64	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	160°C	-		
Ex. 65	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	170°C	-		
Ex. 66	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	180°C	-		
Ex. 67	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	190°C	-		
Ex. 68	A2	B1	1.0	2	3000	Ti	0.05	0.07	Z1	0.07	1.4	Z1	0.35	200°C	-		

Table 5

	Organic silicon compound (W)						Fluorocompound (X)		Phosphoric acid (Y)		V compound (Z)			Coating am't	Drying temperature	Co-compound (C)
	Silane coupling agent		Ratio (A)/(B)	Functional group (a) no.	Molecular weight	Type	Ratio (X)/(W)	Ratio (Y)/(W)	Type	Ratio						
										(Z)/(W)	(Z)/(X)					
												(C)/(W)				
Comp. Ex. 1	A1	-	-	1	500	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Comp. Ex. 2	A1	B1	0.4	2	2000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Comp. Ex. 3	A1	B1	3.0	2	3400	Zr	0.03	0.06	Z1	0.07	2.3	0.35	120°C	-		
Comp. Ex. 4	A1	B1	1.0	2	3000	-	-	0.06	Z1	0.07	-	0.35	120°C	-		
Comp. Ex. 5	A1	B1	1.0	2	3000	Zr	0.03	-	Z1	0.07	2.3	0.35	120°C	-		
Comp. Ex. 6	A1	B1	1.0	2	3000	Zr	0.03	0.06	-	-	-	0.35	120°C	-		
Comp. Ex. 7	A1	B1	1.0	2	3000	Zr	0.03	0.06	Z1	0.07	2.3	0.03	120°C	-		
Comp. Ex. 8	A1	B1	1.0	2	3000	Zr	0.03	0.06	Z1	0.07	2.3	2.5	120°C	-		
Comp. Ex. 9	A1	B1	1.0	2	3000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	50°C	-		
Comp. Ex. 10	A1	B1	1.0	2	3000	Zr	0.03	0.06	Z1	0.07	2.3	0.35	250°C	-		

Table 6

	EG						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 1	A	B	A	B	A	A	A
Ex. 2	A	B	A	B	A	A	A
Ex. 3	A	A	A	A	A	A	A
Ex. 4	A	A	A	A	A	A	A
Ex. 5	A	A	A	A	A	A	A
Ex. 6	A	A	A	A	A	A	A
Ex. 7	A	A	A	A	A	A	A
Ex. 8	A	A	A	A	A	A	A
Ex. 9	A	B	A	B	A	A	A
Ex. 10	A	B	A	B	A	A	A
Ex. 11	A	A	A	A	A	A	A
Ex. 12	A	A	A	A	A	A	A
Ex. 13	A	A	A	A	A	A	A
Ex. 14	B	B	A	A	A	A	A
Ex. 15	A	A	A	A	A	A	A
Ex. 16	A	A	A	A	A	A	A
Ex. 17	B	A	A	A	A	A	A
Ex. 18	A	A	A	A	A	A	A
Ex. 19	A	A	A	A	A	A	A
Ex. 20	A	A	A	A	A	A	A
Ex. 21	A	A	A	A	A	A	A
Ex. 22	A	A	A	A	A	A	A
Ex. 23	A	A	A	B	A	B	A
Ex. 24	A	A	A	B	A	B	A
Ex. 25	A	A	A	A	A	A	A
Ex. 26	A	B	A	A	A	A	A
Ex. 27	A	A	A	A	A	A	A
Ex. 28	A	A	A	A	A	B	A
Ex. 29	A	A	B	A	A	B	A
Ex. 30	A	A	B	A	A	B	A
Ex. 31	B	B	B	A	A	B	A
Ex. 32	B	B	B	A	A	B	A
Ex. 33	B	B	B	A	A	A	A
Ex. 34	B	B	B	A	A	A	A

Table 7

	EG						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 35	B	B	B	A	A	A	A
Ex. 36	A	B	B	A	A	A	A
Ex. 37	A	B	B	A	A	A	A
Ex. 38	A	B	B	A	A	B	A
Ex. 39	A	A	A	A	A	A	A
Ex. 40	A	A	A	A	A	A	A
Ex. 41	A	A	A	A	A	A	A
Ex. 42	A	B	A	A	A	A	A
Ex. 43	A	B	A	A	A	A	A
Ex. 44	A	B	A	A	A	A	A
Ex. 45	B	B	B	B	A	A	A
Ex. 46	B	B	B	B	A	A	A
Ex. 47	B	A	B	B	A	A	A
Ex. 48	A	A	A	B	A	A	A
Ex. 49	A	A	A	A	A	A	A
Ex. 50	A	A	A	A	A	A	A
Ex. 51	A	A	A	A	A	A	A
Ex. 52	A	A	A	A	A	A	A
Ex. 53	A	B	A	A	B	A	A
Ex. 54	A	B	A	A	B	A	B
Ex. 55	A	B	A	B	A	B	B
Ex. 56	A	A	A	B	A	B	B
Ex. 57	A	A	A	A	A	B	A
Ex. 58	A	A	A	A	A	B	A
Ex. 59	A	A	A	A	A	B	A
Ex. 60	A	A	A	A	A	A	A
Ex. 61	A	A	A	A	A	A	A
Ex. 62	A	A	A	A	A	A	A
Ex. 63	A	B	A	A	A	A	A
Ex. 64	A	B	A	A	A	A	A
Ex. 65	A	B	A	A	A	A	A
Ex. 66	A	B	A	A	A	A	A
Ex. 67	A	B	A	B	A	A	A
Ex. 68	A	B	A	B	A	A	A

Table 8

	EG						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Comp. Ex. 1	D	D	D	D	B	D	B
Comp. Ex. 2	A	A	A	D	A	A	B
Comp. Ex. 3	C	C	B	A	A	C	D
Comp. Ex. 4	D	D	D	A	A	A	B
Comp. Ex. 5	C	D	D	A	A	A	B
Comp. Ex. 6	C	D	D	A	A	A	B
Comp. Ex. 7	D	D	D	D	A	B	A
Comp. Ex. 8	A	B	A	A	D	B	D
Comp. Ex. 9	D	D	C	C	A	C	D
Comp. Ex. 10	C	D	C	D	A	A	D

Table 9

	GI						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 1	A	B	A	B	A	A	A
Ex. 2	A	B	A	B	A	A	A
Ex. 3	A	A	A	A	A	A	A
Ex. 4	A	A	A	A	A	A	A
Ex. 5	A	A	A	A	A	A	A
Ex. 6	A	A	A	A	A	A	A
Ex. 7	A	A	A	A	A	A	A
Ex. 8	A	A	A	A	A	A	A
Ex. 9	A	B	A	B	A	A	A
Ex. 10	A	B	A	B	A	A	A
Ex. 11	A	A	A	A	A	A	A
Ex. 12	A	A	A	A	A	A	A
Ex. 13	A	A	A	A	A	A	A
Ex. 14	A	B	A	A	A	A	A
Ex. 15	A	A	A	A	A	A	A
Ex. 16	A	A	A	A	A	A	A
Ex. 17	A	A	A	A	A	A	A
Ex. 18	A	A	A	A	A	A	A
Ex. 19	A	A	A	A	A	A	A
Ex. 20	A	A	A	A	A	A	A
Ex. 21	A	A	A	A	A	A	A
Ex. 22	A	A	A	A	A	A	A
Ex. 23	A	A	A	B	A	B	A
Ex. 24	A	A	A	B	A	B	A
Ex. 25	A	A	A	A	A	A	A
Ex. 26	A	B	A	A	A	A	A
Ex. 27	A	A	A	A	A	A	A
Ex. 28	A	A	A	A	A	B	A
Ex. 29	A	A	B	A	A	B	A
Ex. 30	A	A	B	A	A	B	A
Ex. 31	B	B	B	A	A	B	A
Ex. 32	B	B	B	A	A	B	A
Ex. 33	A	B	B	A	A	A	A
Ex. 34	A	B	B	A	A	A	A

Table 10

	GI						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 35	A	B	B	A	A	A	A
Ex. 36	A	B	B	A	A	A	A
Ex. 37	A	B	B	A	A	A	A
Ex. 38	A	B	B	A	A	B	A
Ex. 39	A	A	A	A	A	A	A
Ex. 40	A	A	A	A	A	A	A
Ex. 41	A	A	A	A	A	A	A
Ex. 42	A	B	A	A	A	A	A
Ex. 43	A	B	A	A	A	A	A
Ex. 44	A	B	A	A	A	A	A
Ex. 45	B	B	B	B	A	A	A
Ex. 46	B	B	B	B	A	A	A
Ex. 47	A	A	B	B	A	A	A
Ex. 48	A	A	A	B	A	A	A
Ex. 49	A	A	A	A	A	A	A
Ex. 50	A	A	A	A	A	A	A
Ex. 51	A	A	A	A	B	A	A
Ex. 52	A	A	A	A	B	A	A
Ex. 53	A	B	A	A	B	A	A
Ex. 54	A	B	A	A	B	A	B
Ex. 55	A	B	A	B	A	B	B
Ex. 56	A	A	A	B	A	B	B
Ex. 57	A	A	A	A	A	B	A
Ex. 58	A	A	A	A	A	B	A
Ex. 59	A	A	A	A	A	B	A
Ex. 60	A	A	A	A	A	A	A
Ex. 61	A	A	A	A	A	A	A
Ex. 62	A	A	A	A	A	A	A
Ex. 63	A	A	A	A	A	A	A
Ex. 64	A	B	A	A	A	A	A
Ex. 65	A	B	A	A	A	A	A
Ex. 66	A	B	A	A	A	A	A
Ex. 67	A	B	A	B	A	A	A
Ex. 68	A	B	A	B	A	A	A

Table 11

	GI						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Comp. Ex. 1	D	D	D	D	B	D	B
Comp. Ex. 2	A	A	A	D	A	A	B
Comp. Ex. 3	C	C	B	A	A	C	D
Comp. Ex. 4	C	C	D	A	A	A	B
Comp. Ex. 5	C	C	D	A	A	A	B
Comp. Ex. 6	C	C	D	A	B	A	B
Comp. Ex. 7	C	C	D	D	A	B	A
Comp. Ex. 8	A	B	A	A	D	B	D
Comp. Ex. 9	D	D	C	C	B	C	D
Comp. Ex. 10	C	C	C	D	B	A	D

Table 12

	ZL						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 1	A	B	A	B	A	A	A
Ex. 2	A	B	A	B	A	A	A
Ex. 3	A	A	A	A	A	A	A
Ex. 4	A	A	A	A	A	A	A
Ex. 5	A	A	A	A	A	A	A
Ex. 6	A	A	A	A	A	A	A
Ex. 7	A	A	A	A	A	A	A
Ex. 8	A	A	A	A	A	A	A
Ex. 9	A	B	A	B	A	A	A
Ex. 10	A	B	A	B	A	A	A
Ex. 11	A	A	A	A	A	A	A
Ex. 12	A	A	A	A	A	A	A
Ex. 13	A	A	A	A	A	A	A
Ex. 14	B	B	A	A	A	A	A
Ex. 15	A	A	A	A	A	A	A
Ex. 16	A	A	A	A	A	A	A
Ex. 17	B	A	A	A	A	A	A
Ex. 18	A	A	A	A	A	A	A
Ex. 19	A	A	A	A	A	A	A
Ex. 20	A	A	A	A	A	A	A
Ex. 21	A	A	A	A	A	A	A
Ex. 22	A	A	A	A	A	A	A
Ex. 23	A	A	A	B	A	B	A
Ex. 24	A	A	A	B	A	B	A
Ex. 25	A	A	A	A	A	A	A
Ex. 26	A	B	A	A	A	A	A
Ex. 27	A	A	A	A	A	A	A
Ex. 28	A	A	A	A	A	B	A
Ex. 29	A	A	A	A	A	B	A
Ex. 30	A	A	A	A	A	B	A
Ex. 31	A	B	A	A	A	B	A
Ex. 32	B	B	A	A	A	B	A
Ex. 33	B	B	A	A	A	A	A
Ex. 34	B	B	A	A	A	A	A

Table 13

	ZL						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 35	B	B	A	A	A	A	A
Ex. 36	A	B	A	A	A	A	A
Ex. 37	A	B	A	A	A	A	A
Ex. 38	A	B	A	A	A	B	A
Ex. 39	A	A	A	A	A	A	A
Ex. 40	A	A	A	A	A	A	A
Ex. 41	A	A	A	A	A	A	A
Ex. 42	A	B	A	A	A	A	A
Ex. 43	A	B	A	A	A	A	A
Ex. 44	A	B	A	A	A	A	A
Ex. 45	B	B	A	B	A	A	A
Ex. 46	B	B	A	B	A	A	A
Ex. 47	B	A	A	B	A	A	A
Ex. 48	A	A	A	B	A	A	A
Ex. 49	A	A	A	A	A	A	A
Ex. 50	A	A	A	A	A	A	A
Ex. 51	A	A	A	A	A	A	A
Ex. 52	A	A	A	A	A	A	A
Ex. 53	A	B	A	A	B	A	A
Ex. 54	A	B	A	A	B	A	A
Ex. 55	A	B	A	B	A	B	A
Ex. 56	A	A	A	B	A	B	A
Ex. 57	A	A	A	A	A	B	A
Ex. 58	A	A	A	A	A	B	A
Ex. 59	A	A	A	A	A	B	A
Ex. 60	A	A	A	A	A	A	A
Ex. 61	A	A	A	A	A	A	A
Ex. 62	A	A	A	A	A	A	A
Ex. 63	A	B	A	A	A	A	A
Ex. 64	A	B	A	A	A	A	A
Ex. 65	A	B	A	A	A	A	A
Ex. 66	A	B	A	A	A	A	A
Ex. 67	A	B	A	B	A	A	A
Ex. 68	A	B	A	B	A	A	A

Table 14

	ZL						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Comp. Ex. 1	D	D	D	D	B	D	B
Comp. Ex. 2	A	A	A	D	A	A	B
Comp. Ex. 3	C	C	B	A	A	C	D
Comp. Ex. 4	D	D	D	A	A	A	B
Comp. Ex. 5	C	D	D	A	A	A	B
Comp. Ex. 6	C	D	D	A	A	A	B
Comp. Ex. 7	D	D	D	D	A	B	A
Comp. Ex. 8	A	B	A	A	D	B	C
Comp. Ex. 9	D	D	C	C	A	C	C
Comp. Ex. 10	C	D	C	D	A	A	C

Table 15

	SD						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 1	A	A	A	B	A	A	A
Ex. 2	A	A	A	B	A	A	A
Ex. 3	A	A	A	A	A	A	A
Ex. 4	A	A	A	A	A	A	A
Ex. 5	A	A	A	A	A	A	A
Ex. 6	A	A	A	A	A	A	A
Ex. 7	A	A	A	A	A	A	A
Ex. 8	A	A	A	A	A	A	A
Ex. 9	A	A	A	B	A	A	A
Ex. 10	A	A	A	B	A	A	A
Ex. 11	A	A	A	A	A	A	A
Ex. 12	A	A	A	A	A	A	A
Ex. 13	A	A	A	A	A	A	A
Ex. 14	A	A	A	A	A	A	A
Ex. 15	A	A	A	A	A	A	A
Ex. 16	A	A	A	A	A	A	A
Ex. 17	A	A	A	A	A	A	A
Ex. 18	A	A	A	A	A	A	A
Ex. 19	A	A	A	A	A	A	A
Ex. 20	A	A	A	A	A	A	A
Ex. 21	A	A	A	A	A	A	A
Ex. 22	A	A	A	A	A	A	A
Ex. 23	A	A	A	B	A	B	A
Ex. 24	A	A	A	B	A	B	A
Ex. 25	A	A	A	A	A	A	A
Ex. 26	A	B	A	A	A	A	A
Ex. 27	A	A	A	A	A	A	A
Ex. 28	A	A	A	A	A	B	A
Ex. 29	A	A	B	A	A	B	A
Ex. 30	A	A	B	A	A	B	A
Ex. 31	B	B	B	A	A	B	A
Ex. 32	B	B	B	A	A	B	A
Ex. 33	A	A	B	A	A	A	A
Ex. 34	A	A	B	A	A	A	A

Table 16

	SD						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Ex. 35	A	A	B	A	A	A	A
Ex. 36	A	A	B	A	A	A	A
Ex. 37	A	A	B	A	A	A	A
Ex. 38	A	A	B	A	A	B	A
Ex. 39	A	A	A	A	A	A	A
Ex. 40	A	A	A	A	A	A	A
Ex. 41	A	A	A	A	A	A	A
Ex. 42	A	A	A	A	A	A	A
Ex. 43	A	A	A	A	A	A	A
Ex. 44	A	A	A	A	A	A	A
Ex. 45	A	A	B	B	A	A	A
Ex. 46	A	A	B	B	A	A	A
Ex. 47	A	A	B	B	A	A	A
Ex. 48	A	A	A	B	A	A	A
Ex. 49	A	A	A	A	A	A	A
Ex. 50	A	A	A	A	A	A	A
Ex. 51	A	A	A	A	B	A	A
Ex. 52	A	A	A	A	B	A	A
Ex. 53	A	A	A	A	B	A	A
Ex. 54	A	A	A	A	B	A	B
Ex. 55	A	A	A	B	A	B	B
Ex. 56	A	A	A	B	A	B	B
Ex. 57	A	A	A	A	A	B	A
Ex. 58	A	A	A	A	A	B	A
Ex. 59	A	A	A	A	A	B	A
Ex. 60	A	A	A	A	A	A	A
Ex. 61	A	A	A	A	A	A	A
Ex. 62	A	A	A	A	A	A	A
Ex. 63	A	A	A	A	A	A	A
Ex. 64	A	A	A	A	A	A	A
Ex. 65	A	A	A	A	A	A	A
Ex. 66	A	A	A	A	A	A	A
Ex. 67	A	A	A	B	A	A	A
Ex. 68	A	A	A	B	A	A	A

Table 17

	SD						
	SST		Heat resistance	Fingermark resistance	Conductivity	Coatability	Blackening
	Flat part	Worked part					
Comp. Ex. 1	D	D	D	D	B	D	B
Comp. Ex. 2	A	A	A	D	A	A	B
Comp. Ex. 3	C	C	B	A	A	C	D
Comp. Ex. 4	C	C	D	A	A	A	B
Comp. Ex. 5	C	C	D	A	A	A	B
Comp. Ex. 6	C	C	D	A	B	A	B
Comp. Ex. 7	C	C	D	D	A	B	A
Comp. Ex. 8	A	B	A	A	D	B	D
Comp. Ex. 9	D	D	C	C	B	C	D
Comp. Ex. 10	C	C	C	D	B	A	D

CLAIMS

1. A surface treated metal material, characterized by being comprised of a metal material having

5 (1) a surface, on which is coated and dried an aqueous metal surface treatment agent,

the aqueous metal surface treatment agent comprising:

10 (2) an organic silicon compound (W), obtained by blending a silane coupling agent (A) containing one amino group in its molecule and a silane coupling agent (B) containing one glycidyl group in its molecule in a solid weight ratio [(A)/(B)] of 0.5 to 1.7 and containing, in its molecule, at least two functional groups (a) of the formula $-\text{SiR}^1\text{R}^2\text{R}^3$ (wherein, R^1 , R^2 , and R^3 independently represent an alkoxy group or hydroxy group, at least one representing an alkoxy group) and one or more of at least one type of hydrophilic functional group (b) selected from hydroxy group (one separate from that able to be included in the functional group (a)) and an amino group, and having an average molecular weight of 1000 to 10000,

(3) at least one type of fluorocompound (X) selected from fluorotitanic acid or fluoro-zirconic acid,

25 (4) phosphoric acid (Y), and

(5) a vanadium compound (Z), so as to form a composite coating containing the different ingredients,

and among the ingredients of the composite coating,

30 (6) the solid weight ratio [(X)/(W)] of the organic silicon compound (W) and fluorocompound (X) being 0.02 to 0.07,

(7) the solid weight ratio [(Y)/(W)] of the organic silicon compound (W) and phosphoric acid (Y) being 0.03 to 0.12,

35 (8) the solid weight ratio [(Z)/(W)] of the organic silicon compound (W) and vanadium compound (Z)

being 0.05 to 0.17, and

(9) the solid weight ratio [(Z)/(X)] of the fluorocompound (X) and vanadium compound (Z) being 1.3 to 6.0.

5 2. A surface treated metal material as set forth in claim 1, further containing, as an ingredient (C), in the coating, at least one type of cobalt compound selected from the group comprised of cobalt sulfate, cobalt nitrate, and cobalt carbonate, where the solid
10 weight ratio [(C)/(W)] of said organic silicon compound (W) and cobalt compound (C) is 0.01 to 0.1.

 3. A surface treated metal material characterized by being comprised of a metal material on the surface of which an aqueous metal surface treatment agent of claim 1
15 or 2 is coated and dried at a peak temperature higher than 50°C and less than 250°C to give a dried coating weight of 0.05 to 2.0 g/m².

 4. A surface treated metal material of claim 1, 2, or 3 wherein said metal material is a zinc-based plated
20 steel sheet.