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DESCRIPTION

SURFACE-TREATED METAL SHEETS WITH EXCELLENT PRESS GALLING RESISTANCE AND HANDLEABILITY, AND PROCESS FOR THEIR MANUFACTURE

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Technical Field

The present invention relates to surface-treated metal sheets suitable for use in automobiles, household electric appliances, construction materials and the like, which exhibit not only excellent performance such as corrosion resistance, adhesion and weldability, but also excellent press galling resistance and handleability, as well as a process for their manufacture and aqueous organic/inorganic compound paints with which the surface-treated metal sheets can be obtained.

The invention further relates to surface-treated metal sheets suitable for use in automobiles, household electric appliances, construction materials and the like, which exhibit not only excellent performance such as corrosion resistance, adhesion and weldability, but also excellent press galling resistance and continuous sliding wear resistance, as well as a process for their manufacture and aqueous organic/inorganic compound paints with which the surface-treated metal sheets can be obtained.

The invention still further relates to surface-treated metal sheets suitable for use in automobiles, household electric appliances, construction materials and the like, which exhibit excellent performance such as corrosion resistance, adhesion and weldability and maintain press galling resistance, while improving the problems of coil smashing due to winding slackness or load collapse during piling of cut sheets, and inhibiting generation of adhesive residue produced by shedding of lubricants from films during pressing.

Background Art



ACTION

Surface-treated steel sheets such as zinc electroplated steel sheets and zinc hot-dip plated steel sheets developed to this date have been widely used for household electric appliances, construction materials, automobile parts and the like. Most of such steel sheets are chromate-treated or phosphate-treated for the purpose of improving corrosion resistance and coating adhesion.

Furthermore, with the recent increase in coating-free applications for the purpose of step reduction and cost reduction, particularly in the electric appliance industry, a higher level of performance is being demanded for the quality of the surface outer appearance of steel sheets, including not only corrosion resistance and coating adhesion, but also galling resistance, fingerprint resistance and susceptibility to discoloration due to condensation or wetting.

In order to meet the performance required by consumer demand, there have been developed coated metal sheets having special resin-based organic compound films on chromate-treated plated steel sheets. For example, in Japanese Examined Patent Publication (Kokai) No. 4-14191 (JP-A-4-14191) there is disclosed a production process for surface-treated steel sheets with improved performance such as corrosion resistance and fingerprint resistance, wherein on a chromate coating-plated steel sheet there is formed an organic compound film prepared by adding a specific fine particulate colloid sol to an aqueous organic resin.

Japanese Unexamined Patent Publication (Kokai) No. 3-39485 (JP-A-3-39485) discloses 0.3-3.0 g/m² dry weight coverage of a paint comprising silica and a wax with a glass transition point (T_g) of 40°C or higher dispersed in an aqueous resin, after chromating treatment on a zinc-based plated steel sheet. Also, Japanese Unexamined Patent Publication (Kokai) No. 3-28380 (JP-A-3-28380) discloses a lubricative coated steel sheet obtained by 0.5-4.0 g/m² dry weight coverage of a paint comprising a

carboxylated polyethylene resin and Teflon™ lubricant, after chromating treatment on a zinc electroplated steel sheet. In order to meet consumer demand requiring strong galling resistance, such as press formability, there have also been developed surface-treated steel sheets with improved lubricative properties by addition of solid lubricants to organic films. For example, in Japanese Unexamined Patent Publication (Kokai) No. 6-173037 (JP-A-6-173037) there is disclosed a steel sheet with a lubricating film obtained by adding silica and polyolefin wax to an ether/ester-type urethane resin and epoxy resin.

The technique disclosed in Japanese Examined Patent Publication (Kokai) No. 4-14191 (JP-A-4-14191) provides a sheet with an excellent balance of performance including corrosion resistance, coating adhesion, fingerprint resistance and susceptibility to discoloration, and it is currently being utilized as one of the major materials for household electrical appliances. However, even such surface-treated steel sheets coated with organic films sometimes exhibit scratching during handling, galling during press working, abrasion during product transport, and the like.

In contrast, the techniques disclosed in Japanese Unexamined Patent Publication (Kokai) No. 3-39485 (JP-A-3-39485) and Japanese Unexamined Patent Publication (Kokai) No. 3-28380 (JP-A-3-28380) exhibit a low degree of such galling during press working or abrasion, while the technique disclosed in Japanese Unexamined Patent Publication (Kokai) No. 6-173037 (JP-A-6-173037) has excellent press galling resistance even under severe working such as press forming. Nevertheless, the steel sheet surfaces produced by the techniques disclosed in Japanese Unexamined Patent Publication (Kokai) No. 3-39485 (JP-A-3-39485), Japanese Unexamined Patent Publication (Kokai) No. 3-28380 (JP-A-3-28380) and Japanese Unexamined Patent Publication (Kokai) No. 6-

173037 (JP-A-6-173037) slide easily and are therefore associated with problems of coil smashing due to winding slackness or load collapse during piling of cut sheets. The measures currently employed in order to avoid these
5 problems include increasing the tension during coil wind-up, and increasing the number of bands to prevent coil slackness after packing.

It is the first major object of the present invention to ensure excellent performance of corrosion
10 resistance, adhesion and weldability, and maintain press galling resistance, while improving the problems of coil smashing due to winding slackness or load collapse during piling of cut sheets, by providing a surface-treated metal sheet with a controlled film composition and a
15 controlled dynamic friction coefficient and static friction coefficient of the film surface, as well as a process for its manufacture and an aqueous organic/inorganic compound paint with which the surface-treated metal sheet can be manufactured.

20 It is the second major object of the invention to provide a surface-treated metal sheet with excellent performance of corrosion resistance, adhesion and weldability, and also excellent press galling resistance and continuous sliding wear resistance, as well as a
25 process for its manufacture and an aqueous organic/inorganic compound paint with which the surface-treated metal sheet can be manufactured.

It is the third major object of the invention to provide a surface-treated metal sheet which exhibits
30 excellent performance such as corrosion resistance, adhesion and weldability and maintains press galling resistance, while improving the problems of coil smashing due to winding slackness or load collapse during piling of cut sheets, and inhibiting generation of adhesive
35 residue produced by shedding of lubricant from the film during pressing, as well as a process for its manufacture.

Disclosure of the Invention

As a result of much diligent research directed toward achieving the aforementioned first object, the present inventors have completed the present invention upon finding that by coating and drying on a plated metal sheet an aqueous organic/inorganic compound paint containing a polyolefin wax dispersion with a molecular weight of 6000-15,000 and an appropriate amount of colloidal silica to form an aqueous organic/inorganic compound film, it is possible to obtain a surface-treated metal sheet which exhibits not only excellent performance such as corrosion resistance, adhesion and weldability, but also excellent press galling resistance and handleability, wherein the metal sheet surface has a dynamic friction coefficient controlled to 0.07-0.15 and a static friction coefficient controlled to 0.10 or higher.

The gist of the present invention according to its first aspect, therefore, is as follows.

(1) A surface-treated metal sheet with excellent press galling resistance and handleability, characterized by having 0.3-5.0 g/m² of an aqueous organic/inorganic compound film containing either or both an aqueous resin and a silicate compound, as well as a polyolefin wax dispersion with a molecular weight of 6000-15,000 and 5-35 wt% of colloidal silica in terms of solid content.

(2) A surface-treated metal sheet with excellent press galling resistance and handleability according to (1) above, characterized in that the polyolefin wax dispersion is at least one type selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μ m, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0

μm.

(3) A surface-treated metal sheet with excellent press galling resistance and handleability according to (1) or (2) above, characterized in that the surface has a dynamic friction coefficient of 0.07-0.15 and a static friction coefficient of 0.10 or higher.

(4) An aqueous organic/inorganic compound paint characterized by containing either or both an aqueous resin and a silicate compound, as well as a polyolefin wax dispersion with a molecular weight of 6000-15,000, 5-35 wt% of colloidal silica in terms of solid content, and water.

(5) An aqueous organic/inorganic compound paint according to (4) above, characterized in that the polyolefin wax dispersion is at least one type selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm.

(6) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and handleability, characterized in that after coating a paint according to (4) above onto a plated metal sheet at 0.3-5.0 g/m² in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

(7) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and handleability, characterized in that after coating a paint according to (5) above onto a plated metal sheet at 0.3-5.0 g/m² in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

As a result of much diligent research directed toward achieving the aforementioned second object, the present inventors have also completed the present

invention upon finding that by coating and drying on a plated metal sheet an aqueous organic/inorganic compound paint containing a polyolefin wax dispersion with a molecular weight of 6000-15,000, a polyolefin wax dispersion with a molecular weight of 1000-5000 and an appropriate amount of colloidal silica to form an aqueous organic/inorganic compound film, it is possible to obtain a surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance.

The gist of the present invention according to its second aspect, therefore, is as follows.

(1) A surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance, characterized by having an aqueous organic/inorganic compound film containing either or both an aqueous resin and a silicate compound, as well as a lubricant (A) composed of a polyolefin wax dispersion with a molecular weight of 6000-15,000, a lubricant (B) composed of a polyolefin wax dispersion with a molecular weight of 1000-5000, and 5-35 wt% of colloidal silica in terms of solid content, and by having the aqueous organic/inorganic compound film at 0.3-5.0 g/m².

(2) A surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance according to (1) above, characterized in that the lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μ m, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μ m, and lubricant (B) is a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-5.0 μ m.

(3) An aqueous organic/inorganic compound paint containing either or both an aqueous resin and a silicate compound, as well as a lubricant (A) composed of a polyolefin wax dispersion with a molecular weight of 6000-15,000, a lubricant (B) composed of a polyolefin wax dispersion with a molecular weight of 1000-5000, 5-35 wt% of colloidal silica in terms of solid content, and water.

(4) An aqueous organic/inorganic compound paint according to (3) above, characterized in that the lubricant (A) is at least one type selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm , and lubricant (B) is a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-5.0 μm .

(5) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance, characterized in that after coating an aqueous organic/inorganic compound paint according to (3) above onto a plated metal sheet at 0.3-5.0 g/m^2 in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

(6) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance, characterized in that after coating an aqueous organic/inorganic compound paint according to (4) above onto a plated metal sheet at 0.3-5.0 g/m^2 in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

As a result of much diligent research directed toward achieving the aforementioned third object, the present inventors have also completed the present invention upon finding that by coating onto the upper

layer of a plated metal sheet an aqueous organic/inorganic compound paint (E) containing a lubricant (A) of a polyolefin wax dispersion with a molecular weight of 6000-15,000, and if necessary a
5 lubricant (B) of a polyolefin wax dispersion with a molecular weight of 1000-5000, baking it to form a first layer, and then coating an aqueous organic/inorganic compound paint (F) containing an appropriate amount of colloidal silica and baking it to form a second layer,
10 there may be obtained a surface-treated metal sheet wherein it is possible to control the dynamic friction coefficient of the metal sheet surface to 0.07-0.15 and the static friction coefficient to 0.10 or higher, while also preventing generation of adhesive residue produced
15 by shedding of lubricant from the film during pressing.

The gist of the present invention according to its third aspect, therefore, is as follows.

(1) A surface-treated metal sheet with excellent press galling resistance and handleability, characterized
20 by having, as a first layer, an aqueous organic/inorganic compound film (C) containing either or both an aqueous resin and a silicate compound and a lubricant (A) composed of a polyolefin wax dispersion with a molecular weight of 6000-15,000, at a dry weight of 0.05-0.3 g/m²,
25 and as a second layer, an aqueous organic/inorganic compound film (D) composed of either or both an aqueous resin and a silicate compound and 5-35 wt% of colloidal silica in terms of solid content, at a dry weight of 0.5-5.0 g/m².

(2) A surface-treated metal sheet with excellent
30 press galling resistance and handleability according to (1) above, characterized in that the lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and
35 having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μ m, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an

acid value of 40 or below and a particle size of 0.1-5.0 μm .

(3) A surface-treated metal sheet with excellent press galling resistance and handleability according to (1) or (2) above, characterized in that the aqueous organic/inorganic compound film (C) is composed of an aqueous resin and a compound lubricant prepared by combining a lubricant (A) of a polyolefin wax dispersion with a molecular weight of 6000-15,000 and a lubricant (B) of a polyolefin wax dispersion with a molecular weight of 1000-5000.

(4) A surface-treated metal sheet with excellent press galling resistance and handleability according to (3) above, characterized in that the lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm , and lubricant (B) is a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-3.0 μm .

(5) A surface-treated metal sheet with excellent press galling resistance and handleability according to any one of (1) to (4) above, characterized in that the surface has a dynamic friction coefficient of 0.07-0.15 and a static friction coefficient of 0.10 or higher.

(6) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and handleability, characterized in that after coating onto a plated metal sheet an aqueous organic/inorganic compound paint (E) composed of either or both an aqueous resin and a silicate compound, as well as a lubricant (A) which is a polyolefin wax dispersion with a molecular weight of 6000-15,000 and water, to 0.05-0.3 g/m² in terms of dry

weight, baking it to form a first layer, and then coating an aqueous organic/inorganic compound paint (F) composed of either or both an aqueous resin and a silicate compound, as well as colloidal silica and water wherein
5 the colloidal silica content is 5-35 wt% in terms of solid content, to 0.5-5.0 g/m² in terms of dry weight, and baking it to form a second layer.

(7) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and
10 handleability according to (6) above, characterized in that the lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm, and modified
15 polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm.

(8) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and
20 handleability according to (6) or (7) above, characterized in that the aqueous organic/inorganic compound paint (E) is composed of an aqueous resin, a compound lubricant prepared by combining a lubricant (A) of a polyolefin wax dispersion with a molecular weight of
25 6000-15,000 and a lubricant (B) of a polyolefin wax dispersion with a molecular weight of 1000-5000, and water.

(9) A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and
30 handleability according to any one of (6) to (8) above, characterized in that the lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of
35 0.1-5.0 μm, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or

below and a particle size of 0.1-5.0 μm , and lubricant (B) is a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-3.0 μm .

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Brief Description of the Drawings

Fig. 1 is an illustration of a surface-treated metal sheet according to the first aspect of the invention.

10 Fig. 2 is an illustration of a surface-treated metal sheet according to the second aspect of the invention.

Fig. 3 is an illustration of an embodiment of a surface-treated metal sheet according to the third aspect of the invention.

15 Fig. 4 is an illustration of another embodiment of a surface-treated metal sheet according to the third aspect of the invention.

Best Mode for Carrying Out the Invention

20 The present invention will now be explained in greater detail.

The conventionally employed method for improving press galling resistance of an aqueous organic/inorganic compound coated steel sheet has been to add a lubricant such as low molecular weight polyolefin wax to the
25 aqueous organic/inorganic compound film on the steel sheet. By adding a low molecular weight polyolefin wax dispersion with no polar groups to the aqueous organic/inorganic film in this manner, the wax is present as particles on the film surface thereby allowing
30 reduction in the affinity of the metal sheet surface, while the wax is also crushed during press working to form a lubricating layer between the steel sheet and the die. An excellent lubricating effect is therefore obtained, so that galling during pressing can be reduced.

35 According to the first aspect of the invention, a polyolefin wax dispersion with a molecular weight of

6000-15,000 is used as a lubricant in a prescribed amount in the aqueous organic/inorganic compound paint. The compound paint is adjusted to have a content of colloidal silica of 5-35 wt% in terms of solid content.

5 Fig. 1 shows an embodiment of a surface-treated metal sheet according to the invention. The surface-treated metal sheet of the invention has a construction with an aqueous organic/inorganic compound film 2 on a plated metal sheet 3. The aqueous organic/inorganic
10 compound film 2 is formed by coating an aqueous organic/inorganic compound paint containing either or both an aqueous resin and a silicate compound, as well as colloidal silica, water and a polyolefin wax dispersion 1 as a lubricant, onto the plated metal sheet 3 by an
15 appropriate method. As shown in Fig. 1, the polyolefin wax dispersion 1 is exposed as particles from the aqueous organic/inorganic compound film 2.

 Thus, a polyolefin wax dispersion is added to the aqueous organic/inorganic compound film, and the
20 molecular weight of the wax is adjusted to an appropriate value to produce the wax in particulate form on the film surface and to control the hardness of the wax and the affinity of the film surface. The silica content is also adjusted, not only for film hardness but also to achieve
25 film performance such as corrosion resistance and adhesion. A surface-treated metal sheet can therefore be obtained having not only satisfactory corrosion resistance and adhesion, but also excellent press galling resistance and handleability not found in the prior art,
30 with a dynamic friction coefficient controlled to 0.07-0.15 and a static friction coefficient controlled to 0.10 or higher.

 A process for manufacturing a surface-treated metal sheet with excellent press galling resistance and
35 handleability according to the first aspect of the invention will now be explained.

 The surface-treated metal sheet according to the

first aspect of the invention is manufactured by coating a prescribed aqueous organic/inorganic compound paint onto a foundational plated metal sheet and baking it to form an aqueous organic/inorganic compound film.

5 Suitable foundational plated metal sheets for the invention include zinc-based electroplated, hot-dip plated and vapor deposition plated steel sheets, aluminum or aluminum alloy plated metal sheets, lead or lead alloy plated metal sheets and tin or tin alloy plated metal
10 sheets, such as zinc plated metal sheets, zinc-nickel plated metal sheets, zinc-iron plated metal sheets, zinc-chromium plated metal sheets, zinc-aluminum plated metal sheets, zinc-titanium plated metal sheets, zinc-magnesium plated metal sheets, zinc-manganese plated metal sheets, etc., as well as those having such plated layers
15 containing small amounts of cobalt, molybdenum, tungsten, nickel, titanium, chromium, aluminum, manganese, iron, magnesium, lead, antimony, tin, copper, cadmium, arsenic or the like as separate metal elements or impurities, and/or having inorganic substances such as silica,
20 alumina or titania dispersed therein. The invention may also be applied to compound plated metal sheets in which the above-mentioned platings are combined with other platings, such as iron platings, iron-phosphorus platings or the like.
25

The plating coverage for each plated metal sheet is preferably at least 1 g/m² per side, since a lower degree of coverage results in reduced corrosion resistance.

30 The surface-treated metal sheet of the invention may be obtained by foundational treatment of the plated metal sheet for the purpose of improving the adhesion or corrosion resistance prior to formation of the aqueous organic/inorganic compound film. Alternatively, it may be obtained by forming the aqueous organic/inorganic
35 compound film directly on the plated metal sheet without foundational treatment. The foundational treatment is not particularly restricted so long as it can achieve the

aforementioned purpose, but chromating treatment is generally preferred since it allows improvement in corrosion resistance or adhesion.

As means for forming chromate films there may be mentioned, for example, immersion (reactive) chromating treatment or electrolytic chromating treatment in an aqueous solution containing chromic anhydride, a chromate salt or a dichromate salt as the principal agent, or an application chromating treatment method wherein a treatment solution comprising a mixture of colloidal silica or the like in said aqueous solution is coated and then dried without washing.

The chromate coverage is preferably about 5-100 mg/m² based on Cr. If the coverage is less than 5 mg/m² based on Cr the resulting corrosion resistance is not sufficient, while if it is greater than 100 mg/m², cohesive failure of the chromate film itself occurs, thus lowering the coating adhesion.

As aqueous resins there may be used acrylic ester-acrylic acid copolymers, epoxy-acrylic acid copolymers, olefin-acrylic acid copolymers, olefin ionomers, styrene-acrylic acid copolymers, urethane-acrylic acid copolymers, urethane-epoxy resins, ethylene-imine-acrylic resins and the like. In order to obtain paints using such aqueous resins it is preferred to disperse the resins in aqueous solvents to form emulsions. Where necessary, various crosslinking agents such as melamine resins or amino resins may also be added. Among these, it is particularly preferred to use acrylic-based resins such as olefin-acrylic acid copolymer from the standpoint of both performance and cost. In cases requiring severe press forming, it is preferred to use urethane-epoxy based resins exhibiting both hardness and elongation.

The silicate compound used for the invention will generally be represented by $M_2O \cdot nSiO_2$ (where M is one of the alkali metals of sodium, potassium and lithium, and n is any desired value), and it is a mixture of one or more

types selected from among sodium silicates, potassium silicates and lithium silicates. The value of "n" as the molar ratio of M_2O and SiO_2 is preferably in the range of 1-10. The value of "n" is preferably not less than 1,
5 because the resulting film tends to absorb moisture and the film adhesion is insufficient. It is preferably not above 10 because the resulting film becomes brittle and the formability is reduced.

The colloidal silica used for the invention may be
10 spherical or filamentous silica, or branched string of bonded beaded colloidal silica. In the case of spherical silica the particle size is preferably 5-50 nm, in the case of filamentous silica the diameter is preferably 5-50 nm, with the filaments being chemically bonded to have
15 a length/thickness ratio of 1-5, and in the case of branched string of beaded silica the ratio of [length of aggregates/mean particle size of beaded silica] is preferably at least 4, with one or more being branched.

The colloidal silica is added at 5-35 wt% in terms
20 of solid content in the aqueous organic/inorganic compound paint of the invention. At less than 5 wt%, sufficient corrosion resistance and press galling resistance cannot be obtained, while at greater than 35 wt% the coating adhesion and press galling resistance are
25 inferior.

The aqueous organic/inorganic compound paint used in the first aspect of the invention is prepared by combining either or both the aforementioned aqueous resin and a silicate compound, as well as colloidal silica and
30 water, with a polyolefin wax dispersion having a molecular weight of 6000-15,000. More preferably, at least one type selected from among polyolefin wax dispersions containing substantially no polar groups and having a molecular weight of 6000-15,000 and a particle
35 size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0

μm , is added to the aqueous organic/inorganic compound paint.

As a polyolefin wax dispersion there may be used a dispersion of a polyethylene wax, polypropylene wax or
5 polybutylene wax containing substantially no polar groups in water or aqueous solution containing an emulsifier at a concentration of no greater than 5%, and preferably containing no emulsifier.

As a modified polyolefin wax dispersion there may be
10 used a dispersion of a polyethylene wax, polypropylene wax or polybutylene wax containing a polar group in water or aqueous solution containing an emulsifier at a concentration of no greater than 5%, and preferably containing no emulsifier. The polar group may be
15 introduced by oxidizing treatment of the polyolefin wax with an oxidizing agent such as oxygen, ozone, nitric acid or the like in the presence of a catalyst (oxidized polyolefin wax), or it may be introduced by dissolution
20 of an ethylenic unsaturated carboxylic acid monomer such as acrylic acid, methacrylic acid, crotonic acid, maleic acid, fumaric acid, itaconic acid or the like and a polyolefin wax in benzole or the like followed by heating
under a nitrogen stream together with a polymerization initiator (peroxide, redox agent, heavy metal catalyst,
25 etc.) for grafting.

The weight average particle size of the polyolefin wax dispersion and modified polyolefin wax dispersion is preferably 0.1-5.0 μm , and more preferably 1.0-4.0 μm . The weight-average particle size is preferably not less
30 than 0.1 μm because this tends to cause aggregation and impair the stability. The weight-average particle size is also preferably not greater than 5.0 μm because the dispersion stability is lowered. The ratio of the weight-average particle size to the number-average
35 particle size is preferably in a range such that weight-average particle size/number-average particle size is

less than 3.

The range of the weight-average molecular weight of the polyolefin wax dispersion and modified polyolefin wax dispersion is preferably 6000-15,000. The weight-average
5 molecular weight is preferably not less than 6000 because this results in inferior handleability. The weight-average molecular weight is preferably not greater than 15,000 because the press galling resistance is impaired.

The method and conditions for analysis of the
10 weight-average molecular weight of the polyolefin wax dispersion and modified polyolefin wax dispersion are described below, although the molecular weight analysis need not be limited to this method.

- Analysis method: High temperature GPC (gel permeation
15 chromatography)
- Column: PS (polystyrene) gel mix type (2-4 column serial connection)
- Solvent: o-dichlorobenzene (ODCB), trichlorobenzene (TCB), etc.
- 20 • Measuring temperature: 130-140°C
- Detector: Differential refractometer instrument (RI) or infrared detector
- Calibration curve: Based on each molecular weight converted using commercially available monodisperse PS

25 The range for the acid value (KOH-mg/g) of the modified polyolefin wax dispersion as specified by JIS K 5902 is preferably 40 or lower. If the acid value exceeds 40 the lubricant becomes hard making it impossible to achieve adequate lubricity.

30 The polyolefin wax dispersion and modified polyolefin wax dispersion also preferably have a density of 950-1000 kg/m³ as specified by JIS K 6760, a hardness (needle hardness) of 0.2 mm or lower as specified by JIS K 2207, a crystallinity of 80% or greater as determined
35 by X-ray diffraction and a melting point of 110-150°C.

At least one type selected from among these polyolefin wax dispersions and modified polyolefin wax

dispersions is preferably included in the aqueous organic/inorganic compound paint at 1-30 wt% in terms of solid content. At less than 1 wt% it is not possible to obtain sufficient press galling resistance, and at greater than 30 wt% the coating adhesion is inferior.

The coverage range for the aqueous organic/inorganic compound film is 0.3-5.0 g/m² in terms of dry weight. It is more preferably 1.0-3.0 g/m². The coverage is preferably not less than 0.3 g/m² in order to achieve the target press galling resistance, and it is preferably not greater than 5.0 g/m² in order to facilitate weldability.

The method used for application to form the aqueous organic/inorganic compound film may be spraying, curtaining, flow coating, roll coating, bar coating, brush application, immersion, air knife coating or the like.

The baking temperature is preferably 80-250°C. It is even more preferably a temperature higher than the melting point of the lubricant which is used. At below 80°C the corrosion resistance is reduced because the water in the paint cannot completely evaporate, while at above 250°C the film hardens too much, thus lowering the formability.

There are no particular restrictions on the drying equipment, and the method applied may be hot-air spraying, indirect heating with a heater, infrared ray heating, inductive heating, or combinations of these methods.

The dynamic friction coefficient of the surface of the surface-treated metal sheet of the invention is preferably 0.07-0.15, and the static friction coefficient is preferably 0.10 or higher. When the dynamic friction coefficient is higher than 0.15 the press galling resistance is inferior, and when the dynamic friction coefficient is lower than 0.07 or the static friction coefficient is lower than 0.10, the handleability is inferior.

According to the second aspect of the invention, prescribed amounts of lubricants (A) and (B) with different molecular weights are added as lubricants to the aqueous organic/inorganic compound paint. Here, a
5 polyolefin wax dispersion with a molecular weight of 6000-15,000 is used as lubricant (A), and a polyolefin wax dispersion with a molecular weight of 1000-5000 is used as lubricant (B). By also adjusting the silica
10 content of the aqueous organic/inorganic compound film to be 5-35 wt% in terms of solid content, it is possible to achieve both film hardness and film performance including corrosion resistance and adhesion.

Fig. 2 shows an embodiment of a surface-treated metal sheet according to the invention. The surface-
15 treated metal sheet of the invention has a construction with an aqueous organic/inorganic compound film 13 on a plated metal sheet 14. The aqueous organic/inorganic compound film 13 is formed by coating an aqueous
20 organic/inorganic compound paint containing either or both an aqueous resin and a silicate compound, as well as lubricant (A), lubricant (B), 5-35 wt% of colloidal silica in terms of solid content, and water, onto the
25 plated metal sheet 14 by an appropriate method. As shown in Fig. 2, the lubricant (A) 11 and lubricant (B) 12 are exposed as particles from the aqueous organic/inorganic compound film 13.

Thus, a conventionally used low molecular weight polyolefin wax dispersion and a high molecular weight polyolefin wax dispersion are both added to the aqueous
30 organic/inorganic compound film, to produce the wax in particulate form on the film surface while inhibiting crushing of the wax during press molding and continuous sliding. The silica content is also adjusted, not only for film hardness but also to achieve film performance
35 such as corrosion resistance and adhesion. It is thereby possible to not only achieve satisfactory corrosion resistance and adhesion, but to also increase the press

galling resistance and the duration of the lubricating effect during periods of continuous sliding.

A process for manufacturing a surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance according to the second aspect of the invention will now be explained. This manufacturing process is basically the same as the manufacturing process for the surface-treated metal sheet according to the first aspect of the invention, except that the aqueous organic/inorganic compound paint used is different.

The surface-treated metal sheet according to the second aspect of the invention is also manufactured by coating a prescribed aqueous organic/inorganic compound paint onto a foundational plated metal sheet and baking it to form an aqueous organic/inorganic compound film.

Suitable foundational plated metal sheets for the invention were mentioned above in regard to a surface-treated metal sheet according to the first aspect. The plating coverage for each plated metal sheet is preferably at least 1 g/m^2 per side, since a lower degree of coverage results in reduced corrosion resistance. The aqueous organic/inorganic compound film may be formed after foundational treatment of the plated metal sheet for the purpose of improving the adhesion or corrosion resistance prior to formation of the aqueous organic/inorganic compound film, or the aqueous organic/inorganic compound film may be formed directly on the plated metal sheet without foundational treatment. The foundational treatment is not particularly restricted so long as it can achieve the aforementioned purpose, but chromating treatment is generally preferred since it allows improvement in corrosion resistance or adhesion. The chromate film-forming means and chromate coverage were explained above in regard to a surface-treated metal sheet according to the first aspect.

As aqueous resins there may be used those mentioned

above in regard to a surface-treated metal sheet according to the first aspect. In order to obtain paints it is likewise preferred to disperse the resins in aqueous solvents to form emulsions, and if necessary, various crosslinking agents such as melamine resins or amino resins may also be added. It is particularly preferred to use acrylic-based resins such as olefin-acrylic acid copolymer from the standpoint of both performance and cost. In cases requiring severe press forming, or in cases requiring greater continuous sliding wear resistance, it is preferred to use urethane-epoxy based resins exhibiting both hardness and elongation.

The silicate compound and colloidal silica used for the second aspect of the invention may be the same as those mentioned above for a surface-treated metal sheet according to the first aspect.

The colloidal silica is added at 5-35 wt% in terms of solid content in the aqueous organic/inorganic compound paint. At less than 5 wt%, sufficient corrosion resistance and press galling resistance cannot be obtained, while at greater than 35 wt% the coating adhesion and press galling resistance are inferior.

The aqueous organic/inorganic compound paint used according to the second aspect of the invention is prepared by combining either or both the aforementioned aqueous resin and a silicate compound, as well as colloidal silica and water, with prescribed amounts of lubricants (A) and (B) having different molecular weights. Here, a polyolefin wax dispersion with a molecular weight of 6000-15,000 is used as lubricant (A), and a polyolefin wax dispersion with a molecular weight of 1000-5000 is used as lubricant (B). More preferably, at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an

acid value of 40 or below and a particle size of 0.1-5.0 μm , is used as lubricant (A), and a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-5.0 μm , is used as lubricant (B).

As a polyolefin wax dispersion there may be used a dispersion of a polyethylene wax, polypropylene wax or polybutylene wax containing substantially no polar groups in water or aqueous solution containing an emulsifier at a concentration of no greater than 5%, and preferably containing no emulsifier.

As a modified polyolefin wax dispersion there may be used a dispersion of a polyethylene wax, polypropylene wax or polybutylene wax containing a polar group in water or aqueous solution containing an emulsifier at a concentration of no greater than 5%, and preferably containing no emulsifier. The polar group may be introduced by oxidizing treatment of the polyolefin wax with an oxidizing agent such as oxygen, ozone, nitric acid or the like in the presence of a catalyst (oxidized polyolefin wax), or it may be introduced by dissolution of an ethylenic unsaturated carboxylic acid monomer such as acrylic acid, methacrylic acid, crotonic acid, maleic acid, fumaric acid, itaconic acid or the like and a polyolefin wax in benzole or the like followed by heating under a nitrogen stream together with a polymerization initiator (peroxide, redox agent, heavy metal catalyst, etc.) for grafting.

The weight average particle size of the polyolefin wax dispersion and modified polyolefin wax dispersion is preferably 0.1-5.0 μm , and more preferably 1.0-4.0 μm . The weight-average particle size is preferably not less than 0.1 μm because this tends to cause aggregation and impair the stability. The weight-average particle size is also preferably not greater than 5.0 μm because the

dispersion stability is lowered. The ratio of the weight-average particle size to the number-average particle size is preferably in a range such that weight-average particle size/number-average particle size is less than 3.

The range of the weight-average molecular weight of the polyolefin wax dispersion and modified polyolefin wax dispersion for lubricant (A) is preferably 6000-15,000. The weight-average molecular weight is preferably not less than 6000 because the lubricant will be too soft, preventing increase in the continuous sliding wear resistance. The weight-average molecular weight is preferably not greater than 15,000 because the press galling resistance is impaired.

The range of the weight-average molecular weight of the polyolefin wax dispersion for lubricant (B) is preferably 1000-5000. The weight-average molecular weight is preferably not less than 1000 because the lubricant will tend to undergo thermal decomposition, and in a direct dry heating furnace where the surface is exposed to high temperatures near 1000°C, it may not always be possible to obtain sufficient lubrication properties. The weight-average molecular weight is preferably not greater than 5000 because the continuous sliding wear resistance is reduced.

The method and conditions for analysis of the weight-average molecular weight of the polyolefin wax dispersion and modified polyolefin wax dispersion have already been explained above in regard to a surface-treated metal sheet according to the first aspect of the invention.

The range for the acid value (KOH-mg/g) of the modified polyolefin wax dispersion for lubricant (A) as specified by JIS K 5902 is preferably 40 or lower. If the acid value exceeds 40 the lubricant hardens making it impossible to achieve adequate lubricity.

The polyolefin wax dispersion and modified

polyolefin wax dispersion for lubricant (A) also preferably has a density of 950-1000 kg/m³ as specified by JIS K 6760, a hardness (needle hardness) of 0.2 mm or lower as specified by JIS K 2207, a crystallinity of 80% or greater as determined by X-ray diffraction and a melting point of 110-150°C.

The total content of lubricants (A) and (B) is preferably 1-30 wt% of the aqueous organic/inorganic compound paint in terms of solid content. At less than 1 wt% it is not possible to achieve sufficient continuous sliding wear resistance, and at greater than 30 wt% the coating adhesion is inferior.

The content of lubricant (A) with respect to the total content of lubricants (A) and (B) is preferably in the range of 10-90%. When it is less than 10%, it becomes impossible to increase the sliding wear resistance. When it is greater than 90%, the press galling resistance is inferior compared to using lubricant (B) alone.

The coverage range for the aqueous organic/inorganic compound film is 0.3-5.0 g/m² in terms of dry weight. It is more preferably 1.0-3.0 g/m². The coverage is preferably not less than 0.3 g/m² in order to achieve the target press galling resistance, and it is preferably not greater than 5.0 g/m² in order to facilitate weldability.

The application method, baking temperature and drying equipment used to form the aqueous organic/inorganic compound film according to the second aspect of the invention have already been explained above in regard to formation of an aqueous organic/inorganic compound film according to the first aspect of the invention.

Next, according to the third aspect of the invention, on the upper layer of a plating metal sheet there is formed, as a first layer, an aqueous organic/inorganic compound film (C) composed of either or both an aqueous resin and a silicate compound and a

lubricant (A) of a polyolefin wax dispersion with a molecular weight of 6000-15,000, at a dry weight of 0.05-0.3 g/m², and then there is formed, as a second layer, an aqueous organic/inorganic compound film (D) composed of either or both an aqueous resin and a silicate compound and colloidal silica, wherein the colloidal silica content is 5-35 wt% in terms of solid content, at a dry weight of 0.5-5.0 g/m².

Fig. 3 shows a first embodiment of a surface-treated metal sheet and Fig. 4 shows a second embodiment of a surface-treated metal sheet, according to the third aspect of the invention.

In Fig. 3, the first embodiment of a surface-treated metal sheet according to the third aspect of the invention has a structure with a first layer of an aqueous organic/inorganic compound film (C) 22 and a second layer of an aqueous organic/inorganic compound film (D) 24 on a plated metal sheet 23. The first layer of the aqueous organic/inorganic compound film (C) 22 is formed by coating a paint (E) composed of either or both an aqueous resin and a silicate compound, as well as a lubricant (A) and water, by an appropriate method and baking it, and the second layer of the aqueous organic/inorganic compound film (D) 24 is formed by coating an aqueous organic/inorganic compound paint (F) composed of either or both an aqueous resin and a silicate compound, as well as colloidal silica and water, by an appropriate method and baking it.

In Fig. 4, the second embodiment of a surface-treated metal sheet according to the third aspect of the invention has a structure with a first layer of an aqueous organic/inorganic compound film (C') 22 and a second layer of an aqueous organic/inorganic compound film (D) 24 on a plated metal sheet 23. The first layer of the aqueous organic/inorganic compound film (C') 22 is formed by coating a paint (E) composed of either or both an aqueous resin and a silicate compound, as well as a

lubricant (A), a lubricant (B) and water, by an appropriate method and baking it, and the second layer of the aqueous organic/inorganic compound film (D) 24 is formed by coating an aqueous organic/inorganic compound paint (F) composed of either or both an aqueous resin and a silicate compound, as well as colloidal silica and water, by an appropriate method and baking it.

Thus, a polyolefin wax dispersion with its molecular weight adjusted to an appropriate value is added to form an aqueous organic/inorganic compound film (C) or (C') and then an aqueous organic/inorganic compound film (D) is formed as an upper layer over this film, to cause the wax to protrude out in particulate form on the film surface from under the aqueous organic/inorganic compound film (D), while the hardness of the wax and the affinity of the film surface are controlled. The silica content of the aqueous organic/inorganic compound film (D) is also adjusted, not only for film hardness but also to achieve film performance such as corrosion resistance and adhesion. A surface-treated metal sheet can therefore be obtained having not only satisfactory corrosion resistance and adhesion, but also excellent press galling resistance and handleability, with a dynamic friction coefficient controlled to 0.07-0.15 and a static friction coefficient controlled to 0.10 or higher, as well as inhibited generation of adhesive residue produced by shedding of the lubricant from the film during pressing.

A process for manufacturing a surface-treated metal sheet with excellent press galling resistance and handleability according to the third aspect of the invention will now be explained. This manufacturing process is basically the same as the manufacturing process for the surface-treated metal sheet according to the first aspect of the invention, except that the aqueous organic/inorganic compound paint used is different, and the aqueous organic/inorganic compound film is formed in two layers.

Suitable foundational plated metal sheets for the invention were mentioned above in regard to a surface-treated metal sheet according to the first aspect. The plating coverage for each plated metal sheet is
5 preferably at least 1 g/m² per side, since a lower degree of coverage results in reduced corrosion resistance. The aqueous organic/inorganic compound film may be formed after foundational treatment of the plated metal sheet for the purpose of improving the adhesion or corrosion
10 resistance prior to formation of the aqueous organic/inorganic compound film, or the aqueous organic/inorganic compound film may be formed directly on the plated metal sheet without foundational treatment. The foundational treatment is not particularly restricted
15 so long as it can achieve the aforementioned purpose, but chromating treatment is generally preferred since it allows improvement in corrosion resistance or adhesion. The chromate film-forming means and chromate coverage were explained above in regard to a surface-treated metal
20 sheet according to the first aspect.

As aqueous resins there may be used those mentioned above in regard to a surface-treated metal sheet according to the first aspect. In order to obtain paints it is likewise preferred to disperse the resins in
25 aqueous solvents to form emulsions, and if necessary, various crosslinking agents such as melamine resins or amino resins may also be added. According to the third aspect of the invention, the aqueous resin used for the first layer is more preferably selected from among highly
30 hydrophilic resins. As resins to be used for the second layer it is particularly preferred to use acrylic-based resins such as olefin-acrylic acid copolymer from the standpoint of both performance and cost, and in cases requiring severe press forming, it is preferred to use
35 urethane-epoxy based resins exhibiting both hardness and elongation.

The silicate compound and colloidal silica used for

the third aspect of the invention may be the same as those mentioned above for a surface-treated metal sheet according to the first aspect.

5 The colloidal silica is added at 5-35 wt% in terms of solid content in the aqueous organic/inorganic compound paint (F). At less than 5 wt%, sufficient corrosion resistance and press galling resistance cannot be obtained, while at greater than 35 wt% the coating adhesion and press galling resistance are inferior.

10 According to the third aspect of the invention, prescribed amounts of lubricant (A) or of lubricants (A) and (B) are used in combination with either or both the aforementioned aqueous resin and a silicate compound, as well as colloidal silica and water, in the aqueous
15 organic/inorganic compound paint (E). Here, a polyolefin wax dispersion with a molecular weight of 6000-15,000 is used as lubricant (A), and a polyolefin wax dispersion with a molecular weight of 1000-5000 is used as lubricant (B). More preferably, at least one type of lubricant
20 selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle
25 size of 0.1-5.0 μm , is used as lubricant (A), and a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-3.0 μm , is used as lubricant (B).

30 As a polyolefin wax dispersion there may be used a dispersion of a polyethylene wax, polypropylene wax or polybutylene wax containing substantially no polar groups in water or aqueous solution containing an emulsifier at a concentration of no greater than 5%, and preferably containing no emulsifier.

35 As a modified polyolefin wax dispersion there may be used a dispersion of a polyethylene wax, polypropylene

wax or polybutylene wax containing a polar group in water or aqueous solution containing an emulsifier at a concentration of no greater than 5%, and preferably containing no emulsifier. The polar group may be
5 introduced by oxidizing treatment of the polyolefin wax with an oxidizing agent such as oxygen, ozone, nitric acid or the like in the presence of a catalyst (oxidized polyolefin wax), or it may be introduced by dissolution
10 of an ethylenic unsaturated carboxylic acid monomer such as acrylic acid, methacrylic acid, crotonic acid, maleic acid, fumaric acid, itaconic acid or the like and a polyolefin wax in benzole or the like followed by heating under a nitrogen stream together with a polymerization initiator (peroxide, redox agent, heavy metal catalyst,
15 etc.) for grafting.

The weight average particle size of the polyolefin wax dispersion and modified polyolefin wax dispersion used for lubricant (A) is preferably 0.1-5.0 μm , and more preferably 1.0-4.0 μm . The particle size of lubricant
20 (A) is selected to be larger than the film thickness of the aqueous organic/inorganic compound film (D) formed as the upper layer. The weight-average particle size of lubricant (A) is preferably not less than 0.1 μm because this tends to cause aggregation and impair the stability.
25 The weight-average particle size of lubricant (A) is also preferably not smaller than the aqueous organic/inorganic compound film (D) formed as the upper layer, because the press galling resistance is impaired. In addition, the weight-average particle size is preferably not greater
30 than 5.0 μm because the dispersion stability is lowered. The ratio of the weight-average particle size to the number-average particle size is preferably in the range of weight-average particle size/number-average particle size < 3 .

35 The weight average particle size of the polyolefin wax dispersion and modified polyolefin wax dispersion of

lubricant (B) is preferably 0.1-3.0 μm . The particle size of lubricant (B) is also selected to be smaller than the film thickness of the aqueous organic/inorganic compound film (D) formed as the upper layer. The weight-average particle size is preferably not less than 0.1 μm because this tends to cause aggregation and impair the stability. The weight-average particle size of lubricant (B) is also preferably not larger than 3.0 μm or larger than the film thickness of the aqueous organic/inorganic compound film (D), because the handleability is impaired.

The range of the weight-average molecular weight of the polyolefin wax dispersion and modified polyolefin wax dispersion for lubricant (A) is preferably 6000-15,000. The weight-average molecular weight is preferably not less than 6000 because the handleability is impaired. The weight-average molecular weight is also preferably not greater than 15,000 because the press galling resistance is impaired.

The range of the weight-average molecular weight of the polyolefin wax dispersion for lubricant (B) is preferably 1000-5000. The weight-average molecular weight is preferably not less than 1000 because the lubricant will tend to undergo thermal decomposition, and in a direct dry heating furnace where the surface is exposed to high temperatures near 1000°C, it may not always be possible to obtain sufficient lubrication properties. The weight-average molecular weight is also preferably not greater than 5000 because the effect of further improved press galling resistance by addition of lubricant (B) cannot be achieved.

The method and conditions for analysis of the weight-average molecular weight of the polyolefin wax dispersion and modified polyolefin wax dispersion have already been explained above in regard to a surface-treated metal sheet according to the first aspect of the invention. The range for the acid value (KOH-mg/g) of

the modified polyolefin wax dispersion for lubricant (A) as specified by JIS K 5902 is preferably 40 or lower. If the acid value exceeds 40 the lubricant becomes too hard making it impossible to achieve adequate lubricity.

5 The polyolefin wax dispersion and modified polyolefin wax dispersion for lubricant (A) also preferably has a density of 950-1000 kg/m³ as specified by JIS K 6760, a hardness (needle hardness) of 0.2 mm or lower as specified by JIS K 2207, a crystallinity of 80%
10 or greater as determined by X-ray diffraction and a melting point of 110-150°C.

 The content of lubricant (A) or the total content of lubricants (A) and (B) is preferably 2-60 wt% of the aqueous organic/inorganic compound paint in terms of
15 solid content. At less than 2 wt% it is not possible to achieve sufficient press galling resistance, and at greater than 60 wt% the coating adhesion is inferior.

 The coverage range for the aqueous organic/inorganic compound film (C) is 0.05-0.3 g/m² in terms of dry
20 weight. It is more preferably 0.05-0.2 g/m². The coverage is preferably not less than 0.05 g/m² in order to achieve the target press galling resistance, and it is preferably not greater than 0.3 g/m² in order to prevent reduced wettability which hampers formation of the upper
25 layer film. The coverage range for the aqueous organic/inorganic compound film (D) is 0.5-5.0 g/m² in terms of dry weight. It is more preferably 1.0-3.0 g/m². The coverage is preferably not less than 0.5 g/m² in order to achieve the target press galling resistance, and
30 it is preferably not greater than 5.0 g/m² in order to facilitate weldability.

 The application method, baking temperature and drying equipment used to form the aqueous
 organic/inorganic compound film according to the third
35 aspect of the invention have already been explained above in regard to formation of an aqueous organic/inorganic compound film according to the first aspect.

The dynamic friction coefficient of the surface of a surface-treated metal sheet according to the third aspect of the invention is preferably 0.07-0.15, and the static friction coefficient is preferably 0.10 or higher. When the dynamic friction coefficient is higher than 0.15 the press galling resistance is inferior, and when the dynamic friction coefficient is lower than 0.07 or the static friction coefficient is lower than 0.10, the handleability is inferior.

Examples

The present invention will now be explained in greater detail by way of examples and comparative examples, with the understanding that the invention is in no way limited by these examples.

First, an embodiment according to the first aspect of the invention will be explained.

(1) Types of agents

A list of the agents used is shown in Table 1. All of the polyolefin wax dispersions except for D1 and D8 had a density of 950-1000 kg/m³ as specified by JIS K 6760, a hardness (needle hardness) of 0.2 mm or lower as specified by JIS K 2207, a crystallinity of 80% or greater as determined by X-ray diffraction and a melting point of 110-150°C.

Table 1 List of agents

Agent	No.	Product name
Organic resins	A1	Acrylic resin (AP-1508(12), Toa Gosei Co., Ltd.)
	A2	Polyolefin-based aqueous resin (AR-2300, Toho Chemical Industry Co., Ltd.)
	A3	Polyurethane-based aqueous resin (RA-85, Nippon-NSC)
	A4	Epoxy-based aqueous resin (DICFINE EM-60, Dainippon Ink and Chemicals Inc.)
Silicate compounds	B1	Lithium silicate
	B2	Sodium silicate
	B3	Potassium silicate
Colloidal silica	C1	Aqueous colloidal silica (SNOWTEX N, Nissan Chemical Industries, Ltd.)
	C2	Aqueous colloidal silica (SNOWTEX UP, Nissan Chemical Industries, Ltd.)
Polyolefin wax dispersions	D1	Polyethylene (Mol.wt.: 1000, Acid value: 0, Size: 3.0 μ m)
	D2	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 3.0 μ m)
	D3	Polyethylene (Mol.wt.: 8000, Acid value: 0, Size: 3.0 μ m)
	D4	Polyethylene (Mol.wt.: 15000, Acid value: 0, Size: 3.0 μ m)
	D5	Polyethylene (Mol.wt.: 20000, Acid value: 0, Size: 3.0 μ m)
	D6	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 0.1 μ m)
	D7	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 5.0 μ m)
	D8	Modified polyethylene (Mol.wt.: 1000, Acid value: 20, Size: 1.0 μ m)
	D9	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 1.0 μ m)
	D10	Modified polyethylene (Mol.wt.: 8000, Acid value: 20, Size: 1.0 μ m)
	D11	Modified polyethylene (Mol.wt.: 15000, Acid value: 20, Size: 1.0 μ m)
	D12	Modified polyethylene (Mol.wt.: 20000, Acid value: 20, Size: 1.0 μ m)
	D13	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 0.1 μ m)
	D14	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 5.0 μ m)
	D15	Modified polyethylene (Mol.wt.: 6000, Acid value: 40, Size: 1.0 μ m)
	D16	Modified polyethylene (Mol.wt.: 6000, Acid value: 100, Size: 1.0 μ m)

(2) Types of metal sheets

The metal sheets used are shown in Table 2.

5

Table 2 Types of metal sheets and plating coverages
(plate thickness: 0.8 mm)

Abbreviation	Type of metal sheet
EG	Zinc electroplated steel sheet (plating coverage: 20 g/m ²)
ZN	Zinc-nickel electroplated steel sheet (plating coverage: 20 g/m ² , nickel content: 12 wt%)
GI	Zinc hot-dip plated steel sheet (plating coverage: 60 g/m ²)

(3) Chromating treatment

10

The EG and ZN in Table 2 were subjected to electrolytic chromating treatment by conduction of a

prescribed electric quantity at a current density of 10 A/dm² in a bath containing 50 g/l of chromic acid and 0.3 g/l of sulfuric acid, and after washing with water, a hot-air drying furnace was used for drying at a peak metal temperature of 80°C.

The GI in Table 2 was coated with a chromating treatment solution containing reduced chromic acid with a reduction of 40% and silica in a SiO₂/CrO₃ ratio of 3, and then dried without washing.

The chromate film coverage was quantified in terms of Cr by fluorescent X-ray analysis.

(4) Preparation of aqueous organic/inorganic compound paints

Either or both an aqueous resin and silicate compound, colloidal silica and a polyolefin wax dispersion from Table 1 were combined in the proportions shown in Tables 4 to 6 to prepare aqueous organic/inorganic compound paints.

(5) Application and drying of aqueous organic/inorganic compound paints

The aqueous organic/inorganic compound paints prepared in (4) above were coated onto the chromate treated plated metal sheets obtained as in (3) above to the dry weights listed in Tables 4-6, and these were baked and dried at a peak metal temperature of 140°C to fabricate samples for evaluation. The organic compound film coverage for each was calculated based on measurement of the liquid film weight during application.

(6) Performance evaluation

a. Plate corrosion resistance

Each of the evaluation samples fabricated in (5) above was tested according to the salt spray test described in JIS Z 2371, in which a 5% NaCl aqueous solution was sprayed onto the painted steel sheet sample at an atmosphere temperature of 35°C and the white rust generation was measured after 72 hours. The evaluation levels of ⊙ and ○ of the following scale were judged as

satisfactory.

◎ : No white rust

○: White rust of less than 10%

△: White rust of $\geq 10\%$ and $< 50\%$

5 ×: White rust of $\geq 50\%$

b. Corrosion resistance after Erichsen drawing

Each of the evaluation sample test pieces fabricated in (5) above was subjected to 6 mm Erichsen drawing, after which a 5% NaCl aqueous solution was sprayed onto the painted steel sheet sample at an atmosphere temperature of 35°C and the white rust generation in the drawn sections was measured after 48 hours. The evaluation levels of ◎ and ○ of the following scale were judged as satisfactory.

15 ◎ : No white rust

○: White rust of less than 5%

△: White rust of $\geq 5\%$ and $< 20\%$

×: White rust of $\geq 20\%$

c. Coating adhesion

20 Each of the evaluation samples fabricated in (5) above was coated with a melamine alkyd resin paint (Amilack #1000 by Kansai Paint Co., Ltd.) to a dry film thickness of 25 μm using a bar coater, the dry film being baked for 20 minutes at a furnace temperature of 130°C. After standing overnight, a sample immersed for 30 minutes in boiling water and another not immersed were both subjected to 7 mm Erichsen drawing and adhesive tape (product name: Cellotape, product of Nichiban Co., Ltd.) was attached to the Erichsen drawn section of each test sample. The adhesive tape was rapidly pulled off at a diagonal direction of 45°, and the outer appearance of the Erichsen drawn section was visually evaluated. The evaluation levels of ◎ and ○ of the following scale were judged as satisfactory.

35 ◎ : No peeling

○: Peeling area of less than 5%

△: Peeling area of $\geq 5\%$ and $< 50\%$

×: Peeling area of $\geq 50\%$

d. Continuous weldability

- 5 Each of the samples fabricated in (5) above was subjected to a continuous spot welding test under the conditions shown in Table 3, and the number of welding points which could be stably formed with a diameter of nugget of 3 mm or greater was determined.

10

Table 3 Welding conditions

Parameter	Conditions
Welding current	8500 A
Electrification time	10 cycles (at 50 Hz)
Electrode diameter	4.5 mm
Electrode force	200 kgf

The evaluation levels of ◎ and ○ of the following scale were judged as satisfactory.

- 15 ◎ : Welding points: ≥ 5000

○: Welding points: ≥ 2500 and < 5000

△: Welding points: ≥ 1000 and < 2500

×: Welding points: < 1000

e. Press galling resistance

- 20 Each of the samples fabricated in (5) above was subjected to a test of rectangular drawing. The conditions for the rectangular drawing test were a blank folder force of 6 tons and a sample (0.8 x 220 x 180 mm) molded to 65 x 115 mm and a height of 50 mm, with the
- 25 sliding surface being visually evaluated after molding. The evaluation levels of ◎ and ○ of the following scale were judged as satisfactory.

◎ : No defects due to galling

- 30 ○: Defects due to galling and sliding scratches on less than 50% of sliding section area

△: Defects due to galling and sliding scratches on

at least 50% of sliding section area

X: Exposure of underlying metal, galling

f. Abrasion resistance test

Each of the samples fabricated in (5) above was
5 subjected to elliptical oscillation 360 times per minute
at a load of 10 g/cm² through a vinyl resin film to
produce abrasion in the sliding area. After 10 minutes
of testing, the sample surface was visually evaluated.
The evaluation levels of ◎ and ○ of the following scale
10 were judged as satisfactory.

◎ : No defects due to galling

○: Defects due to galling on less than 50% of
sliding section area

△: Defects due to galling on at least 50% of
15 sliding section area

X: Exposure of underlying metal

g. Static friction coefficient

A 25 cm² area of each sample fabricated in (5) above
with the burrs removed was attached to a flat testing
20 tool, and a 10D HEIDON static friction coefficient
measuring apparatus by Shinto Scientific Co., Ltd. was
used for measurement of the static friction coefficient
at 0.5°/sec between the samples fabricated in (5) above,
under conditions with a load of 200 g.

25 h. Dynamic friction coefficient

A 14S HEIDON dynamic friction coefficient measuring
apparatus by Shinto Scientific Co., Ltd. was used for
measurement of the dynamic friction coefficient of each
of the samples fabricated in (5) above, under conditions
30 of 10 mm diameter stainless steel ball sliding, a load of
100 g and a sliding speed of 150 mm/min.

i. Handleability

Several 10 t coils with an inner diameter of 508 mm
and a sheet thickness of 1 mm were manufactured having
35 different friction coefficients, and after raising and
lowering each coil 3 times with a crane, the degree of

shift (distance) of the tip end in the coil winding direction (lengthwise direction) which was produced by slackness of the outermost wind was measured and the relationship of the degree of shift with the dynamic friction coefficient and static friction coefficient was examined. As a result, a good correlation was found between the dynamic friction coefficient, the static friction coefficient and the degree of shift (distance) of the coil tip in the winding direction (lengthwise direction) produced by winding slackness. With a dynamic friction coefficient of less than 0.07 and a static friction coefficient of less than 0.10, the shift of the coil tip due to winding slackness was over 50 mm, but when the dynamic friction coefficient was 0.07 or greater and the static friction coefficient was 0.10 or greater, the shift of the coil tip due to winding slackness was successfully limited to less than 30 mm. In the laboratory experiment, the static friction coefficient and dynamic friction coefficient measured by "g" and "h" above were therefore used as indicators of the handleability. The evaluation level of O in the following scale was judged as satisfactory.

O: Dynamic friction coefficient: ≥ 0.07 , static friction coefficient: ≥ 0.1

X: Dynamic friction coefficient: < 0.07 , static friction coefficient: < 0.1

The evaluation results are shown in Tables 7 to 9. As these results clearly demonstrate, the technique of the present invention can give surface-treated metal sheets with excellent performance including corrosion resistance, adhesion and weldability, as well as excellent press galling resistance and handleability, wherein the metal sheet surface has a dynamic friction coefficient controlled to 0.07-0.15 and a static friction coefficient controlled to 0.1 or higher.

Table 4

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film												Coverage (g/m ²)
			Aqueous resin/silicate compound ¹⁾				Silica ²⁾		Wax ³⁾						
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount			
1	EG	40	A1	100	-	-	C1	15	D1	10	-	-	1.0		
2	EG	40	A1	100	-	-	C1	15	D2	10	-	-	1.0		
3	EG	40	A1	100	-	-	C1	15	D3	10	-	-	1.0		
4	EG	40	A1	100	-	-	C1	15	D4	10	-	-	1.0		
5	EG	40	A1	100	-	-	C1	15	D5	10	-	-	1.0		
6	EG	40	A1	100	-	-	C1	15	D6	10	-	-	1.0		
7	EG	40	A1	100	-	-	C1	15	D7	10	-	-	1.0		
8	EG	40	A1	100	-	-	C1	15	D8	10	-	-	1.0		
9	EG	40	A1	100	-	-	C1	15	D9	10	-	-	1.0		
10	EG	40	A1	100	-	-	C1	15	D10	10	-	-	1.0		
11	EG	40	A1	100	-	-	C1	15	D11	10	-	-	1.0		
12	EG	40	A1	100	-	-	C1	15	D12	10	-	-	1.0		
13	EG	40	A1	100	-	-	C1	15	D13	10	-	-	1.0		
14	EG	40	A1	100	-	-	C1	15	D14	10	-	-	1.0		
15	EG	40	A1	100	-	-	C1	15	D15	10	-	-	1.0		
16	EG	40	A1	100	-	-	C1	15	D16	10	-	-	1.0		
17	EG	40	A1	100	-	-	C1	15	D3	1	-	-	1.0		
18	EG	40	A1	100	-	-	C1	15	D3	6	-	-	1.0		
19	EG	40	A1	100	-	-	C1	15	D3	30	-	-	1.0		
20	EG	40	A1	100	-	-	C1	15	D4	1	-	-	1.0		
21	EG	40	A1	100	-	-	C1	15	D4	6	-	-	1.0		
22	EG	40	A1	100	-	-	C1	15	D4	30	-	-	1.0		
23	EG	40	A1	100	-	-	C1	15	D9	1	-	-	1.0		
24	EG	40	A1	100	-	-	C1	15	D9	6	-	-	1.0		
25	EG	40	A1	100	-	-	C1	15	D9	30	-	-	1.0		

1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silicate compound.

2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 5

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film												Coverage (g/m ²)
			Aqueous resin/silicate compound ¹⁾						Silica ²⁾		Wax ³⁾				
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	
26	EG	40	A1	100	-	-	C1	15	D2	5	D4	5	5	1.0	
27	EG	40	A1	100	-	-	C1	15	D2	5	D9	5	5	1.0	
28	EG	40	A1	100	-	-	C1	15	D3	10	-	-	-	0.1	
29	EG	40	A1	100	-	-	C1	15	D3	10	-	-	-	0.3	
30	EG	40	A1	100	-	-	C1	15	D3	10	-	-	-	2.0	
31	EG	40	A1	100	-	-	C1	15	D3	10	-	-	-	5.0	
32	EG	40	A1	100	-	-	C1	15	D3	10	-	-	-	10.0	
33	EG	40	A1	100	-	-	C1	15	D4	10	-	-	-	0.1	
34	EG	40	A1	100	-	-	C1	15	D4	10	-	-	-	0.3	
35	EG	40	A1	100	-	-	C1	15	D4	10	-	-	-	2.0	
36	EG	40	A1	100	-	-	C1	15	D4	10	-	-	-	5.0	
37	EG	40	A1	100	-	-	C1	15	D4	10	-	-	-	10.0	
38	EG	40	A1	100	-	-	C1	15	D9	10	-	-	-	0.1	
39	EG	40	A1	100	-	-	C1	15	D9	10	-	-	-	0.3	
40	EG	40	A1	100	-	-	C1	15	D9	10	-	-	-	2.0	
41	EG	40	A1	100	-	-	C1	15	D9	10	-	-	-	5.0	
42	EG	40	A1	100	-	-	C1	15	D9	10	-	-	-	10.0	
43	EG	40	A1	100	-	-	C1	0	D3	10	-	-	-	1.0	
44	EG	40	A1	100	-	-	C1	5	D3	10	-	-	-	1.0	
45	EG	40	A1	100	-	-	C1	10	D3	10	-	-	-	1.0	
46	EG	40	A1	100	-	-	C1	35	D3	10	-	-	-	1.0	
47	EG	40	A1	100	-	-	C1	50	D3	10	-	-	-	1.0	
48	EG	40	A1	100	-	-	C2	0	D4	10	-	-	-	1.0	
49	EG	40	A1	100	-	-	C2	5	D4	10	-	-	-	1.0	
50	EG	40	A1	100	-	-	C2	10	D4	10	-	-	-	1.0	

1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silicate compound.

2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 6

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film												
			Aqueous resin/silicate compound ¹⁾						Silica ²⁾			Wax ³⁾			Coverage (g/m ²)
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	
51	EG	40	A1	100	-	-	-	C2	35	D4	10	-	-	1.0	
52	EG	40	A1	100	-	-	-	C2	50	D4	10	-	-	1.0	
53	EG	40	A2	90	A4	A4	10	C1	15	D3	10	-	-	1.0	
54	EG	40	A2	90	A4	A4	10	C1	15	D4	10	-	-	1.0	
55	EG	40	A2	90	A4	A4	10	C1	15	D9	10	-	-	1.0	
56	EG	40	A3	90	A4	A4	10	C1	15	D3	10	-	-	1.0	
57	EG	40	A3	90	A4	A4	10	C1	15	D4	10	-	-	1.0	
58	EG	40	A3	90	A4	A4	10	C1	15	D9	10	-	-	1.0	
59	EG	40	B1	100	-	-	-	C1	15	D3	10	-	-	1.0	
60	EG	40	B2	100	-	-	-	C1	15	D3	10	-	-	1.0	
61	EG	40	B3	100	-	-	-	C1	15	D3	10	-	-	1.0	
62	EG	40	B1	90	A1	A1	10	C1	15	D3	10	-	-	1.0	
63	EG	40	B1	90	A4	A4	10	C1	15	D3	10	-	-	1.0	
64	EG	-	A3	90	A4	A4	10	C1	15	D3	10	-	-	1.0	
65	EG	-	A3	90	A4	A4	10	C1	15	D4	10	-	-	1.0	
66	EG	-	A3	90	A4	A4	10	C1	15	D9	10	-	-	1.0	
67	ZN	40	A3	90	A4	A4	10	C1	15	D3	10	-	-	1.0	
68	GI	40	A3	90	A4	A4	10	C1	15	D3	10	-	-	1.0	

1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silicate compound.

2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 7

No.	Performance										Note
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Handle-ability	Dynamic friction coefficient	Static friction coefficient	
1	⊙	⊙	⊙	⊙	⊙	⊙	⊙	X	0.05	0.07	Comp.Ex.
2	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.07	0.15	Invention
3	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.20	Invention
4	⊙	⊙	⊙	⊙	⊙	○	⊙	○	0.15	0.25	Invention
5	⊙	⊙	⊙	⊙	⊙	△	○	○	0.20	0.30	Comp.Ex.
6	⊙	⊙	⊙	⊙	⊙	○	⊙	○	0.08	0.15	Invention
7	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.07	0.12	Invention
8	⊙	⊙	⊙	⊙	⊙	⊙	⊙	X	0.06	0.10	Comp.Ex.
9	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.09	0.20	Invention
10	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.25	Invention
11	⊙	⊙	⊙	⊙	⊙	○	○	○	0.15	0.30	Invention
12	⊙	⊙	⊙	⊙	⊙	X	△	○	0.20	0.35	Comp.Ex.
13	⊙	⊙	⊙	⊙	⊙	○	○	○	0.08	0.20	Invention
14	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.07	0.17	Invention
15	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.15	0.30	Invention
16	⊙	⊙	⊙	⊙	⊙	X	X	○	0.20	0.35	Invention
17	⊙	⊙	⊙	⊙	⊙	○	○	○	0.15	0.30	Invention
18	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.25	Invention
19	○	○	○	○	⊙	⊙	⊙	○	0.08	0.15	Invention
20	⊙	⊙	⊙	⊙	⊙	○	○	○	0.15	0.30	Invention
21	⊙	⊙	⊙	⊙	⊙	○	⊙	○	0.15	0.30	Invention
22	○	○	○	○	⊙	⊙	⊙	○	0.08	0.15	Invention
23	⊙	⊙	⊙	⊙	⊙	○	○	○	0.15	0.30	Invention
24	⊙	⊙	⊙	⊙	⊙	○	⊙	○	0.15	0.30	Invention
25	○	○	○	○	⊙	⊙	⊙	○	0.08	0.15	Invention

Table 8

No.	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Handle-ability	Dynamic friction coefficient	Static friction coefficient	Note
			Without immersion	With immersion							
26	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.07	0.15	Invention
27	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.07	0.18	Invention
28	X	X	△	△	⊙	X	X	○	0.25	0.40	Comp.Ex.
29	○	○	○	○	⊙	○	○	○	0.15	0.30	Invention
30	⊙	⊙	⊙	⊙	○	⊙	⊙	○	0.10	0.20	Invention
31	⊙	⊙	⊙	○	○	⊙	⊙	○	0.10	0.20	Invention
32	⊙	⊙	⊙	○	X	⊙	⊙	○	0.10	0.20	Comp.Ex.
33	X	X	△	△	⊙	X	X	○	0.25	0.45	Comp.Ex.
34	○	○	○	○	⊙	○	○	○	0.15	0.35	Invention
35	⊙	⊙	⊙	⊙	○	⊙	⊙	○	0.15	0.25	Invention
36	⊙	⊙	⊙	○	○	⊙	⊙	○	0.10	0.20	Invention
37	⊙	⊙	⊙	○	X	⊙	⊙	○	0.10	0.20	Comp.Ex.
38	X	X	△	△	⊙	X	X	○	0.25	0.45	Comp.Ex.
39	○	○	○	○	⊙	○	○	○	0.15	0.35	Invention
40	⊙	⊙	⊙	⊙	○	⊙	⊙	○	0.09	0.20	Invention
41	⊙	⊙	⊙	○	○	⊙	⊙	○	0.09	0.20	Invention
42	⊙	⊙	⊙	○	X	⊙	⊙	○	0.09	0.20	Comp.Ex.
43	△	△	⊙	○	⊙	△	○	○	0.10	0.20	Comp.Ex.
44	○	○	⊙	⊙	⊙	○	○	○	0.10	0.20	Invention
45	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.20	Invention
46	⊙	⊙	⊙	○	⊙	⊙	⊙	○	0.10	0.20	Invention
47	○	○	○	△	○	△	○	○	0.10	0.20	Comp.Ex.
48	△	△	⊙	○	⊙	△	○	○	0.15	0.25	Comp.Ex.
49	○	○	⊙	⊙	⊙	○	○	○	0.15	0.25	Invention
50	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.15	0.25	Invention

Table 9

No.	Performance										Note
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion Without immersion	Coating adhesion With immersion	Weldability	Press galling resistance	Abrasion resistance	Handle-ability	Dynamic friction coefficient	Static friction coefficient	
51	⊙	⊙	⊙	○	⊙	⊙	⊙	○	0.15	0.25	Invention
52	○	○	○	△	○	△	○	○	0.15	0.25	Comp. Ex.
53	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.15	Invention
54	⊙	⊙	⊙	⊙	⊙	○	⊙	○	0.15	0.20	Invention
55	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.09	0.15	Invention
56	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.20	Invention
57	⊙	⊙	⊙	⊙	⊙	○	⊙	○	0.15	0.25	Invention
58	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.09	0.20	Invention
59	⊙	○	○	△	⊙	⊙	⊙	○	0.10	0.25	Invention
60	⊙	○	○	△	⊙	⊙	⊙	○	0.10	0.25	Invention
61	⊙	○	○	△	⊙	⊙	⊙	○	0.10	0.25	Invention
62	⊙	⊙	⊙	○	⊙	⊙	⊙	○	0.10	0.25	Invention
63	⊙	⊙	⊙	○	⊙	⊙	⊙	○	0.10	0.25	Invention
64	△	△	⊙	○	⊙	⊙	⊙	○	0.10	0.20	Invention
65	△	△	⊙	○	⊙	○	⊙	○	0.15	0.25	Invention
66	△	△	⊙	○	⊙	⊙	⊙	○	0.09	0.20	Invention
67	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.20	Invention
68	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	0.10	0.20	Invention

An embodiment according to the second aspect of the invention will now be explained.

(1) Types of agents

A list of the agents used is shown in Table 10. All of the lubricants (A) except for D7 had a density of 950-1000 kg/m³ as specified by JIS K 6760, a hardness (needle hardness) of 0.2 mm or lower as specified by JIS K 2207, a crystallinity of 80% or greater as determined by X-ray diffraction and a melting point of 110-150°C.

10

Table 10 List of agents

Agent	No.	Product name
Organic resins	A1	Acrylic resin (AP-1508(12), Toa Gosei Co., Ltd.)
	A2	Polyolefin-based aqueous resin (AR-2300, Toho Chemical Industry Co., Ltd.)
	A3	Polyurethane-based aqueous resin (RA-85, Nippon-NSC)
	A4	Epoxy-based aqueous resin (DICFINE EM-60, Dainippon Ink and Chemicals Inc.)
Silicate compounds	B1	Lithium silicate
	B2	Sodium silicate
	B3	Potassium silicate
Colloidal silica	C1	Aqueous colloidal silica (SNOWTEX N, Nissan Chemical Industries, Ltd.)
	C2	Aqueous colloidal silica (SNOWTEX UP, Nissan Chemical Industries, Ltd.)
Lubricant A & comparisons	D1	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 3.0 μm)
	D2	Polyethylene (Mol.wt.: 8000, Acid value: 0, Size: 3.0 μm)
	D3	Polyethylene (Mol.wt.: 15000, Acid value: 0, Size: 3.0 μm)
	D4	Polyethylene (Mol.wt.: 20000, Acid value: 0, Size: 3.0 μm)
	D5	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 0.1 μm)
	D6	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 5.0 μm)
	D7	Modified polyethylene (Mol.wt.: 1000, Acid value: 20, Size: 1.0 μm)
	D8	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 1.0 μm)
	D9	Modified polyethylene (Mol.wt.: 8000, Acid value: 20, Size: 1.0 μm)
	D10	Modified polyethylene (Mol.wt.: 15000, Acid value: 20, Size: 1.0 μm)
	D11	Modified polyethylene (Mol.wt.: 20000, Acid value: 20, Size: 1.0 μm)
	D12	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 0.1 μm)
	D13	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 5.0 μm)
	D14	Modified polyethylene (Mol.wt.: 6000, Acid value: 40, Size: 1.0 μm)
	D15	Modified polyethylene (Mol.wt.: 6000, Acid value: 100, Size: 1.0 μm)
Lubricant B & comparisons	E16	Polyethylene (Mol.wt.: 500, Acid value: 0, Size: 3.0 μm)
	E17	Polyethylene (Mol.wt.: 1000, Acid value: 0, Size: 3.0 μm)
	E18	Polyethylene (Mol.wt.: 5000, Acid value: 0, Size: 3.0 μm)
	E19	Polyethylene (Mol.wt.: 1000, Acid value: 0, Size: 5.0 μm)
	E20	Polyethylene (Mol.wt.: 1000, Acid value: 0, Size: 0.1 μm)
	E21	Polyethylene (Mol.wt.: 5500, Acid value: 0, Size: 3.0 μm)

(2) Types of metal sheets

The metal sheets used were those listed in Table 2.

(3) Chromating treatment

5 This was carried out as explained above for the first aspect.

(4) Preparation of aqueous organic/inorganic compound paints

10 Either or both an aqueous resin and silicate compound, colloidal silica and a lubricant from Table 10 were combined in the proportions shown in Tables 11 to 13 to prepare aqueous organic/inorganic compound paints.

(5) Application and drying of aqueous organic/inorganic compound paints

15 The aqueous organic/inorganic compound paints prepared in (4) above were coated onto the chromate treated plated metal sheets obtained as in (3) above to the dry weights listed in Tables 11 to 13, and these were baked and dried in a hot-air circulating dry oven at an
20 atmosphere temperature of 500°C and at a peak metal temperature of 140°C to fabricate samples for evaluation. The organic compound film coverage for each was calculated based on measurement of the liquid film weight during application.

25 (6) Performance evaluation

a. Plate corrosion resistance

This was evaluated in the manner explained for the embodiment according to the first aspect.

b. Corrosion resistance after Erichsen drawing

30 This was also evaluated in the manner explained for the embodiment according to the first aspect.

c. Coating adhesion

This was also evaluated in the manner explained for the embodiment according to the first aspect.

35 d. Continuous weldability

This was also evaluated in the manner explained for the embodiment according to the first aspect.

e. Press galling resistance

This was also evaluated in the manner explained for the embodiment according to the first aspect.

f. Abrasion resistance test

5 This was also evaluated in the manner explained for the embodiment according to the first aspect.

g. Continuous sliding wear resistance

10 A 10 mm punched-out plastic article (video tape case) was attached to the end of a 500 g load in a rotating sliding wear tester, and then placed onto the surface of a sample which had been formed into a disk. The sample surface was observed every 50 rotations at 60 rotations per minute, and the number of rotations at which scratches occur in the plating was evaluated.

15 h. Dynamic friction coefficient

This was evaluated in the manner explained for the embodiment according to the first aspect.

i. Thermal decomposition stability

20 Each of the samples fabricated in (5) above was subjected to heat treatment in a direct dry heating furnace with an atmosphere temperature of 900°C and an air ratio of 1.0-1.5, at a peak metal temperature of 140°C, and an evaluation of unsatisfactory (X) was assigned if the dynamic friction coefficient was higher and the press galling resistance and continuous sliding wear resistance were reduced, while an evaluation of satisfactory (O) was assigned if they were unchanged.

25 O: Dynamic friction coefficient, press galling resistance and continuous sliding wear resistance
30 unchanged after heat treatment

X: Higher dynamic friction coefficient and reduced press galling resistance and continuous sliding wear resistance after heat treatment

35 The evaluation results are shown in Tables 14 to 16. As these results clearly demonstrate, the technique of the present invention can give surface-treated metal

sheets with excellent performance including corrosion resistance, adhesion and weldability, as well as excellent press galling resistance and continuous sliding wear resistance.

Table 11

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film														Coverage (g/m ²)		
			Aqueous resin/silicate compound ¹⁾						Silica ²⁾				Lubricant (A) ³⁾					Lubricant (B) ³⁾	
			Amount		Type	Amount		Type	Amount	Type	Amount	Type	Amount	Type	Amount				
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount			
1	EG	40	A1	100	-	-	C1	15	D1	5	-	-	E17	5	1.0				
2	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E17	5	1.0				
3	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E17	5	1.0				
4	EG	40	A1	100	-	-	C1	15	D4	5	-	-	E17	5	1.0				
5	EG	40	A1	100	-	-	C1	15	D5	5	-	-	E17	5	1.0				
6	EG	40	A1	100	-	-	C1	15	D6	5	-	-	E17	5	1.0				
7	EG	40	A1	100	-	-	C1	15	D7	5	-	-	E17	5	1.0				
8	EG	40	A1	100	-	-	C1	15	D8	5	-	-	E17	5	1.0				
9	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E17	5	1.0				
10	EG	40	A1	100	-	-	C1	15	D10	5	-	-	E17	5	1.0				
11	EG	40	A1	100	-	-	C1	15	D11	5	-	-	E17	5	1.0				
12	EG	40	A1	100	-	-	C1	15	D12	5	-	-	E17	5	1.0				
13	EG	40	A1	100	-	-	C1	15	D13	5	-	-	E17	5	1.0				
14	EG	40	A1	100	-	-	C1	15	D14	5	-	-	E17	5	1.0				
15	EG	40	A1	100	-	-	C1	15	D15	5	-	-	E17	5	1.0				
16	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E16	5	1.0				
17	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E18	5	1.0				
18	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E19	5	1.0				
19	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E20	5	1.0				
20	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E21	5	1.0				
21	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E16	5	1.0				
22	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E18	5	1.0				
23	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E19	5	1.0				
24	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E20	5	1.0				
25	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E21	5	1.0				
26	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E16	5	1.0				
27	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E18	5	1.0				
28	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E19	5	1.0				
29	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E20	5	1.0				
30	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E21	5	1.0				

- 1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silicate compound.
- 2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.
- 3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 12

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film														Coverage (g/m ²)
			Aqueous resin/silicate compound ¹⁾				Silica ²⁾		Lubricant (A) ³⁾						Lubricant (B) ³⁾		
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	
31	EG	40	A1	100	-	-	C1	15	D2	1	-	-	E17	9	-	1.0	
32	EG	40	A1	100	-	-	C1	15	D2	9	-	-	E17	1	-	1.0	
33	EG	40	A1	100	-	-	C1	15	D3	1	-	-	E17	9	-	1.0	
34	EG	40	A1	100	-	-	C1	15	D3	9	-	-	E17	1	-	1.0	
35	EG	40	A1	100	-	-	C1	15	D2	2.5	D8	2.5	E17	5	-	1.0	
36	EG	40	A1	100	-	-	C1	15	D3	2.5	D8	2.5	E17	5	-	1.0	
37	EG	40	A1	100	-	-	C1	15	D2	0.5	-	-	E17	0.5	-	1.0	
38	EG	40	A1	100	-	-	C1	15	D2	3.0	-	-	E17	3	-	1.0	
39	EG	40	A1	100	-	-	C1	15	D2	15.0	-	-	E17	15	-	1.0	
40	EG	40	A1	100	-	-	C1	15	D3	0.5	-	-	E17	0.5	-	1.0	
41	EG	40	A1	100	-	-	C1	15	D3	3.0	-	-	E17	3	-	1.0	
42	EG	40	A1	100	-	-	C1	15	D3	15.0	-	-	E17	15	-	1.0	
43	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E17	5	-	0.1	
44	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E17	5	-	0.3	
45	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E17	5	-	2.0	
46	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E17	5	-	5.0	
47	EG	40	A1	100	-	-	C1	15	D2	5	-	-	E17	5	-	10.0	
48	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E17	5	-	0.1	
49	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E17	5	-	0.3	
50	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E17	5	-	2.0	
51	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E17	5	-	5.0	
52	EG	40	A1	100	-	-	C1	15	D3	5	-	-	E17	5	-	10.0	
53	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E17	5	-	0.1	
54	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E17	5	-	0.3	
55	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E17	5	-	2.0	
56	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E17	5	-	5.0	
57	EG	40	A1	100	-	-	C1	15	D9	5	-	-	E17	5	-	10.0	
58	EG	40	A1	100	-	-	C1	0	D2	5	-	-	E17	5	-	1.0	
59	EG	40	A1	100	-	-	C1	5	D2	5	-	-	E17	5	-	1.0	
60	EG	40	A1	100	-	-	C1	10	D2	5	-	-	E17	5	-	1.0	

1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silica compound.

2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 13

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film												Coverage (g/m ²)
			Aqueous resin/silicate compound ¹⁾				Silica ²⁾		Lubricant (A) ³⁾				Lubricant (B) ³⁾		
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	
61	EG	40	A1	100	-	-	C1	35	D2	5	-	E17	5	1.0	
62	EG	40	A1	100	-	-	C1	50	D2	5	-	E17	5	1.0	
63	EG	40	A1	100	-	-	C2	0	D2	5	-	E17	5	1.0	
64	EG	40	A1	100	-	-	C2	5	D2	5	-	E17	5	1.0	
65	EG	40	A1	100	-	-	C2	10	D2	5	-	E17	5	1.0	
66	EG	40	A1	100	-	-	C2	35	D2	5	-	E17	5	1.0	
67	EG	40	A1	100	-	-	C2	50	D2	5	-	E17	5	1.0	
68	EG	40	A2	90	A4	10	C1	15	D2	5	-	E17	5	1.0	
69	EG	40	A2	90	A4	10	C1	15	D3	5	-	E17	5	1.0	
70	EG	40	A2	90	A4	10	C1	15	D9	5	-	E17	5	1.0	
71	EG	40	A3	90	A4	10	C1	15	D2	5	-	E17	5	1.0	
72	EG	40	A3	90	A4	10	C1	15	D3	5	-	E17	5	1.0	
73	EG	40	A3	90	A4	10	C1	15	D9	5	-	E17	5	1.0	
74	EG	40	B1	100	-	-	C1	15	D2	5	-	E17	5	1.0	
75	EG	40	B2	100	-	-	C1	15	D2	5	-	E17	5	1.0	
76	EG	40	B3	100	-	-	C1	15	D2	5	-	E17	5	1.0	
77	EG	40	B1	90	A1	10	C1	15	D2	5	-	E17	5	1.0	
78	EG	40	B1	90	A4	10	C1	15	D2	5	-	E17	5	1.0	
79	EG	-	A3	90	A4	10	C1	15	D2	5	-	E17	5	1.0	
80	EG	-	A3	90	A4	10	C1	15	D3	5	-	E17	5	1.0	
81	EG	-	A3	90	A4	10	C1	15	D9	5	-	E17	5	1.0	
82	ZN	40	A3	90	A4	10	C1	15	D2	5	-	E17	5	1.0	
83	GI	40	A3	90	A4	10	C1	15	D2	5	-	E17	5	1.0	

1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silicate compound.

2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 14

No.	Performance										Note
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Continuous sliding passes	Dynamic friction coefficient	Thermal decomposition stability	
1	⊙	⊙	⊙	⊙	⊙	⊙	⊙	800	0.05	○	Invention
2	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.05	○	Invention
3	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.05	○	Invention
4	⊙	⊙	⊙	⊙	⊙	○	⊙	400	0.07	○	Comp.Ex.
5	⊙	⊙	⊙	⊙	⊙	⊙	⊙	500	0.05	○	Invention
6	⊙	⊙	⊙	⊙	⊙	⊙	⊙	800	0.05	○	Invention
7	⊙	⊙	⊙	⊙	⊙	⊙	⊙	400	0.05	○	Comp.Ex.
8	⊙	⊙	⊙	⊙	⊙	⊙	⊙	500	0.05	○	Invention
9	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.05	○	Invention
10	⊙	⊙	⊙	⊙	⊙	⊙	⊙	900	0.06	○	Invention
11	⊙	⊙	⊙	⊙	⊙	○	⊙	450	0.07	○	Comp.Ex.
12	⊙	⊙	⊙	⊙	⊙	⊙	⊙	500	0.05	○	Invention
13	⊙	⊙	⊙	⊙	⊙	⊙	⊙	600	0.05	○	Invention
14	⊙	⊙	⊙	⊙	⊙	⊙	⊙	600	0.06	○	Invention
15	⊙	⊙	⊙	⊙	⊙	○	⊙	400	0.08	○	Invention
16	⊙	⊙	⊙	⊙	⊙	⊙	⊙	800	0.05	×	Comp.Ex.
17	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1200	0.06	○	Invention
18	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1100	0.05	○	Invention
19	⊙	⊙	⊙	⊙	⊙	○	⊙	700	0.06	○	Invention
20	⊙	⊙	⊙	⊙	⊙	⊙	⊙	450	0.10	○	Comp.Ex.
21	⊙	⊙	⊙	⊙	⊙	⊙	⊙	800	0.05	×	Comp.Ex.
22	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1200	0.07	○	Invention
23	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1100	0.06	○	Invention
24	⊙	⊙	⊙	⊙	⊙	○	⊙	700	0.07	○	Invention
25	⊙	⊙	⊙	⊙	⊙	⊙	⊙	450	0.15	○	Comp.Ex.
26	⊙	⊙	⊙	⊙	⊙	⊙	⊙	800	0.05	×	Comp.Ex.
27	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1200	0.07	○	Invention
28	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1100	0.06	○	Invention
29	⊙	⊙	⊙	⊙	⊙	○	⊙	700	0.07	○	Invention
30	⊙	⊙	⊙	⊙	⊙	⊙	⊙	450	0.10	○	Comp.Ex.

Table 15

No.	Performance										Note
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Continuous sliding passes	Dynamic friction coefficient	Thermal decomposition stability	
			Without immersion	With immersion							
31	⊙	⊙	⊙	⊙	⊙	○	⊙	800	0.05	○	Invention
32	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.06	○	Invention
33	⊙	⊙	⊙	⊙	⊙	○	⊙	900	0.05	○	Invention
34	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1200	0.06	○	Invention
35	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.05	○	Invention
36	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1200	0.06	○	Invention
37	⊙	⊙	⊙	⊙	⊙	○	○	800	0.06	○	Invention
38	⊙	⊙	⊙	⊙	⊙	○	⊙	1100	0.05	○	Invention
39	○	○	⊙	○	⊙	⊙	⊙	1500	0.05	○	Invention
40	⊙	⊙	⊙	⊙	⊙	○	○	800	0.06	○	Invention
41	⊙	⊙	⊙	⊙	⊙	○	⊙	1100	0.05	○	Invention
42	○	○	⊙	○	⊙	⊙	⊙	1500	0.05	○	Invention
43	X	X	△	△	⊙	X	X	100	0.08	○	Comp. Ex.
44	○	○	○	○	⊙	○	○	500	0.06	○	Invention
45	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.05	○	Invention
46	⊙	⊙	⊙	○	○	⊙	⊙	1500	0.05	○	Invention
47	⊙	⊙	⊙	○	X	⊙	⊙	1800	0.06	○	Comp. Ex.
48	X	X	△	△	⊙	X	X	100	0.08	○	Comp. Ex.
49	○	○	○	○	⊙	○	○	500	0.06	○	Invention
50	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.05	○	Invention
51	⊙	⊙	⊙	○	○	⊙	⊙	1500	0.05	○	Invention
52	⊙	⊙	⊙	○	X	⊙	⊙	1800	0.06	○	Comp. Ex.
53	X	X	△	△	⊙	X	X	100	0.08	○	Comp. Ex.
54	○	○	○	○	⊙	○	○	500	0.06	○	Invention
55	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.05	○	Invention
56	⊙	⊙	⊙	○	○	⊙	⊙	1500	0.05	○	Invention
57	⊙	⊙	⊙	○	X	⊙	⊙	1800	0.06	○	Comp. Ex.
58	△	△	⊙	○	⊙	△	○	800	0.10	○	Comp. Ex.
59	○	○	⊙	⊙	⊙	○	○	1000	0.10	○	Invention
60	⊙	⊙	⊙	⊙	⊙	⊙	⊙	1000	0.10	○	Invention

Table 16

No.	Performance										Note
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Continuous sliding passes	Dynamic friction coefficient	Thermal decomposition stability	
			Without immersion	With immersion							
61	◎	◎	◎	○	◎	◎	◎	1000	0.10	○	Invention
62	○	○	○	△	○	△	○	1000	0.10	○	Comp.Ex.
63	△	△	◎	○	◎	△	○	800	0.10	○	Comp.Ex.
64	○	○	◎	◎	◎	○	○	1000	0.10	○	Invention
65	◎	◎	◎	◎	◎	◎	◎	1000	0.10	○	Invention
66	◎	◎	◎	○	◎	◎	◎	1000	0.10	○	Invention
67	○	○	○	△	○	△	○	1000	0.10	○	Comp.Ex.
68	◎	◎	◎	◎	◎	◎	◎	1000	0.05	○	Invention
69	◎	◎	◎	◎	◎	○	◎	1000	0.07	○	Invention
70	◎	◎	◎	◎	◎	◎	◎	1000	0.05	○	Invention
71	◎	◎	◎	◎	◎	◎	◎	1000	0.05	○	Invention
72	◎	◎	◎	◎	◎	○	◎	1000	0.07	○	Invention
73	◎	◎	◎	◎	◎	◎	◎	1000	0.05	○	Invention
74	◎	○	○	△	◎	◎	◎	2000	0.06	○	Invention
75	◎	○	○	△	◎	◎	◎	2000	0.06	○	Invention
76	◎	○	○	△	◎	◎	◎	2000	0.06	○	Invention
77	◎	◎	◎	○	◎	◎	◎	1800	0.06	○	Invention
78	◎	◎	◎	○	◎	◎	◎	1800	0.06	○	Invention
79	△	△	◎	○	◎	◎	◎	1000	0.05	○	Invention
80	△	△	◎	○	◎	○	◎	1000	0.05	○	Invention
81	△	△	◎	○	◎	◎	◎	1000	0.05	○	Invention
82	◎	◎	◎	◎	◎	◎	◎	1500	0.05	○	Invention
83	◎	◎	◎	◎	◎	◎	◎	2000	0.05	○	Invention

An embodiment according to the third aspect of the invention will now be explained.

(1) Types of agents

A list of the agents used is shown in Table 17. All of the lubricants (A) except for D7 had a density of 950-1000 kg/m³ as specified by JIS K 6760, a hardness (needle hardness) of 0.2 mm or lower as specified by JIS K 2207, a crystallinity of 80% or greater as determined by X-ray diffraction and a melting point of 110-150°C.

10

Table 17 List of agents

Agent	No.	Product name
Organic resin	A1	Acrylic resin (AP-1508(12), Toa Gosei Co., Ltd.)
	A2	Polyolefin-based aqueous resin (AR-2300, Toho Chemical Industry Co., Ltd.)
	A3	Polyurethane-based aqueous resin (RA-85, Nippon-NSC)
	A4	Epoxy-based aqueous resin (DICFINE EM-60, Dainippon Ink and Chemicals Inc.)
Silicate compound	B1	Lithium silicate
	B2	Sodium silicate
	B3	Potassium silicate
Colloidal silica	C1	Aqueous colloidal silica (SNOWTEX N, Nissan Chemical Industries, Ltd.)
	C2	Aqueous colloidal silica (SNOWTEX UP, Nissan Chemical Industries, Ltd.)
Lubricant (A) & comparisons	D1	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 3.0 μm)
	D2	Polyethylene (Mol.wt.: 8000, Acid value: 0, Size: 3.0 μm)
	D3	Polyethylene (Mol.wt.: 15000, Acid value: 0, Size: 3.0 μm)
	D4	Polyethylene (Mol.wt.: 20000, Acid value: 0, Size: 3.0 μm)
	D5	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 0.1 μm)
	D6	Polyethylene (Mol.wt.: 6000, Acid value: 0, Size: 5.0 μm)
	D7	Modified polyethylene (Mol.wt.: 1000, Acid value: 20, Size: 3.0 μm)
	D8	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 3.0 μm)
	D9	Modified polyethylene (Mol.wt.: 8000, Acid value: 20, Size: 3.0 μm)
	D10	Modified polyethylene (Mol.wt.: 15000, Acid value: 20, Size: 3.0 μm)
	D11	Modified polyethylene (Mol.wt.: 20000, Acid value: 20, Size: 3.0 μm)
	D12	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 0.1 μm)
	D13	Modified polyethylene (Mol.wt.: 6000, Acid value: 20, Size: 5.0 μm)
	D14	Modified polyethylene (Mol.wt.: 6000, Acid value: 40, Size: 3.0 μm)
	D15	Modified polyethylene (Mol.wt.: 6000, Acid value: 100, Size: 3.0 μm)
Lubricant (B) & comparisons	E16	Polyethylene (Mol.wt.: 1000, Acid value: 0, Size: 0.6 μm)
	E17	Polyethylene (Mol.wt.: 5000, Acid value: 0, Size: 0.6 μm)
	E18	Polyethylene (Mol.wt.: 1000, Acid value: 0, Size: 3.0 μm)
	E19	Polyethylene (Mol.wt.: 1000, Acid value: 0, Size: 0.1 μm)

(2) Types of metal sheets

The metal sheets used were those listed in Table 2.

(3) Chromating treatment

This was carried out as explained above for the first aspect.

5 (4) Preparation of aqueous organic/inorganic compound paints

Either or both an aqueous resin and silicate compound, colloidal silica and a lubricant from Table 17 were combined in the proportions shown in Tables 18 to 20 to prepare aqueous organic/inorganic compound paints.

10 (5) Application and drying of aqueous organic/inorganic compound paints

The aqueous organic/inorganic compound paints prepared in (4) above were coated onto the chromate treated plated metal sheets obtained as in (3) above to the dry weights listed in Tables 18 to 20, and these were baked and dried at a peak metal temperature of 140°C to fabricate samples for evaluation. The organic compound film coverage for each was calculated based on measurement of the liquid film weight during application.

20 (6) Performance evaluation

a. Plate corrosion resistance

This was evaluated in the manner explained for the embodiment according to the first aspect.

25 b. Corrosion resistance after Erichsen drawing

This was also evaluated in the manner explained for the embodiment according to the first aspect.

c. Coating adhesion

This was also evaluated in the manner explained for the embodiment according to the first aspect.

30 d. Continuous weldability

This was also evaluated in the manner explained for the embodiment according to the first aspect.

e. Press galling resistance

35 This was also evaluated in the manner explained for the embodiment according to the first aspect.

f. Surface layer lubricant peel resistance test

Each of the samples fabricated in (5) above was continuously subjected to the aforementioned rectangular drawing test 100 times. The state of peeling of the surface layer lubricant adhering to the die after the continuous drawing was visually evaluated. The evaluation level of O in the following scale was judged as satisfactory.

O: No accumulation of adhesive lubricant matter

X: Accumulation of adhesive lubricant matter

g. Abrasion resistance test

This was also evaluated in the manner explained for the embodiment according to the first aspect.

h. Static friction coefficient

This was also evaluated in the manner explained for the embodiment according to the first aspect.

i. Dynamic friction coefficient

This was also evaluated in the manner explained for the embodiment according to the first aspect.

j. Handleability

This was also evaluated in the manner explained for the embodiment according to the first aspect.

The evaluation results are shown in Tables 21 to 23. As these results clearly demonstrate, the technique of the present invention can give surface-treated metal sheets with excellent performance including corrosion resistance, adhesion and weldability, as well as excellent press galling resistance and handleability, while also inhibiting generation of adhesive residue produced by shedding of lubricant from films during pressing.

Table 18

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film (C)										Organic/inorganic compound film (D)					
			Aqueous resin/silicate compound ¹⁾				Lubricant (A) ³⁾				Lubricant (B) ³⁾		Coverage (g/m ²)		Aqueous resin/silicate compound ¹⁾		Silica ²⁾	
			Type		Amount		Type		Amount		Type		Amount		Type		Amount	
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Amount
1	EG	40	A1	100	-	-	D1	40	-	-	-	-	0.2	-	A1	100	-	15
2	EG	40	A1	100	-	-	D2	40	-	-	-	-	0.2	-	A1	100	-	15
3	EG	40	A1	100	-	-	D3	40	-	-	-	-	0.2	-	A1	100	-	15
4	EG	40	A1	100	-	-	D4	40	-	-	-	-	0.2	-	A1	100	-	15
5	EG	40	A1	100	-	-	D5	40	-	-	-	-	0.2	-	A1	100	-	15
6	EG	40	A1	100	-	-	D6	40	-	-	-	-	0.2	-	A1	100	-	15
7	EG	40	A1	100	-	-	D7	40	-	-	-	-	0.2	-	A1	100	-	15
8	EG	40	A1	100	-	-	D8	40	-	-	-	-	0.2	-	A1	100	-	15
9	EG	40	A1	100	-	-	D9	40	-	-	-	-	0.2	-	A1	100	-	15
10	EG	40	A1	100	-	-	D10	40	-	-	-	-	0.2	-	A1	100	-	15
11	EG	40	A1	100	-	-	D11	40	-	-	-	-	0.2	-	A1	100	-	15
12	EG	40	A1	100	-	-	D12	40	-	-	-	-	0.2	-	A1	100	-	15
13	EG	40	A1	100	-	-	D13	40	-	-	-	-	0.2	-	A1	100	-	15
14	EG	40	A1	100	-	-	D14	40	-	-	-	-	0.2	-	A1	100	-	15
15	EG	40	A1	100	-	-	D15	40	-	-	-	-	0.2	-	A1	100	-	15
16	EG	40	A1	100	-	-	D2	30	-	-	-	E16	10	-	A1	100	-	15
17	EG	40	A1	100	-	-	D2	30	-	-	-	E17	10	-	A1	100	-	15
18	EG	40	A1	100	-	-	D6	30	-	-	-	E18	10	-	A1	100	-	15
19	EG	40	A1	100	-	-	D2	30	-	-	-	E19	10	-	A1	100	-	15
20	EG	40	A1	100	-	-	D2	30	-	-	-	E20	10	-	A1	100	-	15
21	EG	40	A1	100	-	-	D9	30	-	-	-	E16	10	-	A1	100	-	15
22	EG	40	A1	100	-	-	D9	30	-	-	-	E17	10	-	A1	100	-	15
23	EG	40	A1	100	-	-	D13	30	-	-	-	E18	10	-	A1	100	-	15
24	EG	40	A1	100	-	-	D9	30	-	-	-	E19	10	-	A1	100	-	15
25	EG	40	A1	100	-	-	D9	30	-	-	-	E20	10	-	A1	100	-	15
26	EG	40	A1	100	-	-	D2	4	-	-	-	E16	36	-	A1	100	-	15
27	EG	40	A1	100	-	-	D2	36	-	-	-	E16	4	-	A1	100	-	15
28	EG	40	A1	100	-	-	D3	4	-	-	-	E16	36	-	A1	100	-	15
29	EG	40	A1	100	-	-	D3	36	-	-	-	E16	4	-	A1	100	-	15
30	EG	40	A1	100	-	-	D2	10	D8	10	E16	20	0.2	-	A1	100	-	15

- 1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silicate compound.
- 2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.
- 3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 19

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film (C)						Organic/inorganic compound film (D)					
			Aqueous resin/silicate compound ¹⁾			Lubricant (A) ³⁾			Lubricant (B) ³⁾			Aqueous resin/silicate compound ¹⁾		
			Type	Amount	Type	Type	Amount	Type	Type	Amount	Coverage (g/m ²)	Type	Amount	Coverage (g/m ²)
31	EG	40	A1	100	-	D3	10	D8	10	E16	20	A1	100	0.2
32	EG	40	A1	100	-	D2	1.0	-	-	E16	1.0	A1	100	0.2
33	EG	40	A1	100	-	D2	10	-	-	E16	10	A1	100	0.2
34	EG	40	A1	100	-	D2	20	-	-	E16	20	A1	100	0.2
35	EG	40	A1	100	-	D2	30	-	-	E16	30	A1	100	0.2
36	EG	40	A1	100	-	D3	1.0	-	-	E16	1.0	A1	100	0.2
37	EG	40	A1	100	-	D3	10	-	-	E16	10	A1	100	0.2
38	EG	40	A1	100	-	D3	20	-	-	E16	20	A1	100	0.2
39	EG	40	A1	100	-	D3	30	-	-	E16	30	A1	100	0.2
40	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.2
41	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.2
42	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.2
43	EG	40	A1	100	-	D6	40	-	-	-	-	A1	100	0.2
44	EG	40	A1	100	-	D6	40	-	-	-	-	A1	100	0.2
45	EG	40	A1	100	-	D9	40	-	-	-	-	A1	100	0.2
46	EG	40	A1	100	-	D9	40	-	-	-	-	A1	100	0.2
47	EG	40	A1	100	-	D9	40	-	-	-	-	A1	100	0.2
48	EG	40	A1	100	-	D13	40	-	-	-	-	A1	100	0.2
49	EG	40	A1	100	-	D13	40	-	-	-	-	A1	100	0.2
50	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.01
51	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.05
52	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.3
53	EG	40	A1	100	-	D9	40	-	-	-	-	A1	100	0.01
54	EG	40	A1	100	-	D9	40	-	-	-	-	A1	100	0.05
55	EG	40	A1	100	-	D9	40	-	-	-	-	A1	100	0.3
56	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.2
57	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.2
58	EG	40	A1	100	-	D2	40	-	-	-	-	A1	100	0.2

- 1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silicate compound.
- 2) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.
- 3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 20

No.	Metal sheet	Cr coverage (mg/m ²)	Organic/inorganic compound film (C)						Organic/inorganic compound film (D)					
			Aqueous resin/silicate compound ¹⁾			Lubricant (A) ³⁾			Lubricant Coverage (g/m ²) (B) ³⁾			Aqueous resin/silicate compound ¹⁾		
			Type	Amount	Type	Amount	Type	Amount	Type	Amount	Type	Type	Amount	Type
59	EG	40	A1	100	-	-	D2	40	-	-	-	A1	100	-
60	EG	40	A1	100	-	-	D2	40	-	-	-	A1	100	-
61	EG	40	A1	100	-	-	D2	40	-	-	-	A1	100	-
62	EG	40	A1	100	-	-	D2	40	-	-	-	A1	100	-
63	EG	40	A1	100	-	-	D2	40	-	-	-	A1	100	-
64	EG	40	A1	100	-	-	D2	40	-	-	-	A1	100	-
65	EG	40	A1	100	-	-	D2	40	-	-	-	A1	100	-
66	EG	40	A2	90	A4	10	D2	40	-	-	-	A2	90	A4
67	EG	40	A2	90	A4	10	D3	40	-	-	-	A2	90	A4
68	EG	40	A2	90	A4	10	D9	40	-	-	-	A2	90	A4
69	EG	40	A3	90	A4	10	D2	40	-	-	-	A3	90	A4
70	EG	40	A3	90	A4	10	D3	40	-	-	-	A3	90	A4
71	EG	40	A3	90	A4	10	D9	40	-	-	-	A3	90	A4
72	EG	40	B1	100	-	-	D2	40	-	-	-	B1	100	-
73	EG	40	B2	100	-	-	D2	40	-	-	-	B2	100	-
74	EG	40	B3	100	-	-	D2	40	-	-	-	B3	100	-
75	EG	40	B1	90	A1	10	D2	40	-	-	-	B1	90	A1
76	EG	40	B1	90	A4	10	D2	40	-	-	-	B1	90	A4
77	EG	-	A3	90	A4	10	D2	40	-	-	-	A3	90	A4
78	EG	-	A3	90	A4	10	D3	40	-	-	-	A3	90	A4
79	EG	-	A3	90	A4	10	D9	40	-	-	-	A3	90	A4
80	ZN	40	A3	90	A4	10	D2	40	-	-	-	A3	90	A4
81	GI	40	A3	90	A4	10	D2	40	-	-	-	A3	90	A4

1) Type and proportion of each aqueous resin added based on, in terms of solid weight, 100 of the total of the aqueous resin and/or silica compound.

2) Type and proportion of silica added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

3) Type and proportion of each globular wax dispersion added based on, in terms of solid weight, 100 of the total of the organic/inorganic compound film.

Table 21

No.	Performance											Note
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Peel resistance	Handle-ability	Dynamic friction coefficient	Static friction coefficient	
			Without immersion	With immersion								
1	◎	◎	◎	◎	◎	◎	◎	◎	○	0.07	0.15	Invention
2	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.20	Invention
3	◎	◎	◎	◎	◎	○	◎	◎	○	0.15	0.25	Invention
4	◎	◎	◎	◎	◎	△	◎	◎	○	0.20	0.30	Comp.Ex.
5	◎	◎	◎	◎	◎	○	◎	◎	○	0.08	0.15	Invention
6	◎	◎	◎	◎	◎	◎	◎	◎	○	0.07	0.12	Invention
7	◎	◎	◎	◎	◎	◎	◎	◎	×	0.06	0.10	Comp.Ex.
8	◎	◎	◎	◎	◎	◎	◎	◎	○	0.09	0.20	Invention
9	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.25	Invention
10	◎	◎	◎	◎	◎	◎	◎	◎	○	0.15	0.30	Invention
11	◎	◎	◎	◎	◎	×	△	◎	○	0.20	0.35	Comp.Ex.
12	◎	◎	◎	◎	◎	○	◎	◎	○	0.08	0.20	Invention
13	◎	◎	◎	◎	◎	◎	◎	◎	○	0.07	0.17	Invention
14	◎	◎	◎	◎	◎	◎	◎	◎	○	0.15	0.30	Invention
15	◎	◎	◎	◎	◎	×	×	◎	○	0.20	0.35	Comp.Ex.
16	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.20	Invention
17	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.20	Invention
18	◎	◎	◎	◎	○	◎	◎	◎	○	0.10	0.20	Invention
19	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.20	Invention
20	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.20	Invention
21	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.25	Invention
22	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.25	Invention
23	◎	◎	◎	◎	○	◎	◎	◎	○	0.10	0.25	Invention
24	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.25	Invention
25	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.25	Invention
26	◎	◎	◎	◎	◎	○	◎	◎	○	0.12	0.25	Invention
27	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.20	Invention
28	◎	◎	◎	◎	◎	○	◎	◎	○	0.20	0.35	Invention
29	◎	◎	◎	◎	◎	◎	◎	◎	○	0.15	0.30	Invention
30	◎	◎	◎	◎	◎	◎	◎	◎	○	0.10	0.20	Invention

Table 22

No.	Performance										Note		
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Peel resistance	Handle-ability	Dynamic friction coefficient		Static friction coefficient	
			Without immersion	With immersion									
31	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.15	0.30	Invention
32	⊙	⊙	⊙	⊙	⊙	○	○	○	○	○	0.15	0.30	Invention
33	⊙	⊙	⊙	⊙	⊙	○	⊙	⊙	○	○	0.12	0.25	Invention
34	○	○	⊙	○	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
35	△	△	○	△	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
36	⊙	⊙	⊙	⊙	⊙	○	○	○	○	○	0.20	0.35	Invention
37	⊙	⊙	⊙	⊙	⊙	○	⊙	⊙	○	○	0.18	0.30	Invention
38	○	○	⊙	○	⊙	⊙	⊙	⊙	○	○	0.15	0.30	Invention
39	△	△	○	△	⊙	⊙	⊙	⊙	○	○	0.15	0.30	Invention
40	X	X	△	△	⊙	X	X	X	X	○	0.08	0.15	Comp.Ex.
41	○	○	○	○	⊙	○	○	○	○	○	0.08	0.15	Invention
42	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
43	⊙	⊙	⊙	○	○	⊙	⊙	⊙	○	○	0.10	0.30	Invention
44	⊙	⊙	⊙	○	X	⊙	⊙	⊙	○	○	0.25	0.35	Comp.Ex.
45	X	X	△	△	⊙	X	X	X	X	○	0.08	0.15	Comp.Ex.
46	○	○	○	○	⊙	○	○	○	○	○	0.08	0.20	Invention
47	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.25	Invention
48	⊙	⊙	⊙	○	○	⊙	⊙	⊙	○	○	0.10	0.25	Invention
49	⊙	⊙	⊙	○	○	⊙	⊙	⊙	○	○	0.25	0.35	Comp.Ex.
50	⊙	⊙	⊙	⊙	⊙	X	X	X	○	○	0.2	0.30	Comp.Ex.
51	⊙	⊙	⊙	⊙	⊙	○	○	○	○	○	0.15	0.25	Invention
52	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.1	0.20	Invention
53	⊙	⊙	⊙	⊙	⊙	X	X	X	○	○	0.20	0.30	Comp.Ex.
54	⊙	⊙	⊙	⊙	⊙	○	○	○	○	○	0.15	0.30	Invention
55	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.25	Invention
56	△	△	⊙	○	⊙	△	○	○	○	○	0.10	0.20	Comp.Ex.
57	○	○	⊙	⊙	⊙	○	○	○	○	○	0.10	0.20	Invention
58	⊙	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention

Table 23

No.	Performance										Note	
	Flat sheet corrosion resistance	Corrosion resistance after Erichsen drawing	Coating adhesion		Weldability	Press galling resistance	Abrasion resistance	Peel resistance	Handle-ability	Dynamic friction coefficient	Static friction coefficient	
			Without immersion	With immersion								
59	⊙	⊙	⊙	○	⊙	⊙	⊙	○	○	0.10	0.20	Invention
60	○	○	○	△	○	△	○	○	○	0.10	0.20	Comp.Ex.
61	△	△	⊙	○	⊙	△	○	○	○	0.10	0.20	Comp.Ex.
62	○	○	⊙	⊙	⊙	○	○	○	○	0.10	0.20	Invention
63	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
64	⊙	⊙	⊙	○	⊙	⊙	⊙	○	○	1.00	0.20	Invention
65	○	○	○	△	○	△	○	○	○	0.10	0.20	Comp.Ex.
66	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
67	⊙	⊙	⊙	⊙	⊙	○	⊙	○	○	0.15	0.25	Invention
68	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
69	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
70	⊙	⊙	⊙	⊙	⊙	○	⊙	○	○	0.15	0.25	Invention
71	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
72	⊙	○	○	△	⊙	⊙	⊙	○	○	0.10	0.25	Invention
73	⊙	○	○	△	⊙	⊙	⊙	○	○	0.15	0.30	Invention
74	⊙	○	○	△	⊙	⊙	⊙	○	○	0.10	0.25	Invention
75	⊙	⊙	⊙	○	⊙	⊙	⊙	○	○	0.10	0.25	Invention
76	⊙	⊙	⊙	○	⊙	⊙	⊙	○	○	0.10	0.25	Invention
77	△	△	⊙	○	⊙	⊙	⊙	○	○	0.10	0.20	Invention
78	△	△	⊙	○	⊙	○	⊙	○	○	0.15	0.25	Invention
79	△	△	⊙	○	⊙	⊙	⊙	○	○	0.10	0.20	Invention
80	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention
81	⊙	⊙	⊙	⊙	⊙	⊙	⊙	○	○	0.10	0.20	Invention

Industrial Applicability

5 The surface-treated metal sheets according to the first aspect of the invention exhibit excellent performance of corrosion resistance, adhesion and weldability and maintain press galling resistance, while also improving the problems of coil smashing due to winding slackness or load collapse during piling of cut sheets, and are therefore suitable as materials in the fields of household electric appliances, construction materials and automobiles. The aqueous organic/inorganic compound paint and manufacturing process according to the first aspect of the invention provide for the market surface-treated metal sheets with satisfactory press galling resistance and handleability.

15 The surface-treated metal sheets according to the second aspect of the invention exhibit excellent performance of corrosion resistance, adhesion and weldability and maintain press galling resistance and continuous sliding wear resistance, and are therefore also suitable as materials in the fields of household electric appliances, construction materials and automobiles. The aqueous organic/inorganic compound paint and manufacturing process according to the second aspect of the invention provide for the market surface-treated metal sheets with satisfactory press galling resistance and continuous sliding wear resistance.

25 The surface-treated metal sheets according to the third aspect of the invention exhibit excellent performance of corrosion resistance, adhesion and weldability and maintain press galling resistance, while improving the problems of coil smashing due to winding slackness or load collapse during piling of cut sheets and inhibiting generation of adhesive residue produced by shedding of lubricant from the films during pressing, and are therefore also suitable as materials in the fields of household electric appliances, construction materials and automobiles. The aqueous organic/inorganic compound

paint and manufacturing process according to the third aspect of the invention provide for the market surface-treated metal sheets with satisfactory press galling resistance and handleability.

CLAIMS

1. A surface-treated metal sheet with excellent press galling resistance and handleability, characterized by having 0.3-5.0 g/m² of an aqueous organic/inorganic compound film containing either or both an aqueous resin and a silicate compound, as well as a polyolefin wax dispersion with a molecular weight of 6000-15,000 and 5-35 wt% of colloidal silica in terms of solid content.

2. A surface-treated metal sheet with excellent press galling resistance and handleability according to claim 1, characterized in that said polyolefin wax dispersion is at least one type selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μ m, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μ m.

3. A surface-treated metal sheet with excellent press galling resistance and handleability according to claim 1 or 2, characterized in that the surface has a dynamic friction coefficient of 0.07-0.15 and a static friction coefficient of 0.10 or higher.

4. An aqueous organic/inorganic compound paint characterized by containing either or both an aqueous resin and a silicate compound, as well as a polyolefin wax dispersion with a molecular weight of 6000-15,000, 5-35 wt% of colloidal silica in terms of solid content, and water.

5. An aqueous organic/inorganic compound paint according to claim 4, characterized in that said polyolefin wax dispersion is at least one type selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μ m, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an

acid value of 40 or below and a particle size of 0.1-5.0 μm .

5 6. A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and handleability, characterized in that after coating a paint according to claim 4 onto a plated metal sheet at 0.3-5.0 g/m² in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

10 7. A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and handleability, characterized in that after coating a paint according to claim 5 onto a plated metal sheet at 0.3-5.0 g/m² in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

15 8. A surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance, characterized by having an aqueous organic/inorganic compound film containing either or both an aqueous resin and a silicate compound, as well as a lubricant (A) composed of a polyolefin wax dispersion with a molecular weight of 6000-15,000, a lubricant (B) composed of a polyolefin wax dispersion with a molecular weight of 1000-5000, and 5-35 wt% of colloidal silica in terms of solid content, and by having said aqueous organic/inorganic compound film at 0.3-5.0 g/m².

20 9. A surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance according to claim 8, characterized in that said lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm , and lubricant (B) is a polyolefin wax dispersion containing no polar groups and having a

35

molecular weight of 1000-5000 and a particle size of 0.1-5.0 μm .

10. An aqueous organic/inorganic compound paint containing either or both an aqueous resin and a silicate compound, as well as a lubricant (A) composed of a
5 polyolefin wax dispersion with a molecular weight of 6000-15,000, a lubricant (B) composed of a polyolefin wax dispersion with a molecular weight of 1000-5000, 5-35 wt% of colloidal silica in terms of solid content, and water.

10 11. An aqueous organic/inorganic compound paint according to claim 10, characterized in that said lubricant (A) is at least one type selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle
15 size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm , and lubricant (B) is a polyolefin wax dispersion containing no polar groups and having a molecular weight
20 of 1000-5000 and a particle size of 0.1-5.0 μm .

12. A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance, characterized in that after coating an aqueous organic/inorganic compound paint
25 according to claim 10 onto a plated metal sheet at 0.3-5.0 g/m^2 in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

13. A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and continuous sliding wear resistance, characterized in that after coating an aqueous organic/inorganic compound paint according to claim 11 onto a plated metal sheet at 0.3-5.0 g/m^2 in terms of dry weight, it is baked to form an aqueous organic/inorganic compound film.

35 14. A surface-treated metal sheet with excellent press galling resistance and handleability, characterized

by having, as a first layer, an aqueous organic/inorganic compound film (C) containing either or both an aqueous resin and a silicate compound and a lubricant (A) composed of a polyolefin wax dispersion with a molecular weight of 6000-15,000, at a dry weight of 0.05-0.3 g/m², and as a second layer, an aqueous organic/inorganic compound film (D) composed of either or both an aqueous resin and a silicate compound and 5-35 wt% of colloidal silica in terms of solid content, at a dry weight of 0.5-5.0 g/m².

15. A surface-treated metal sheet with excellent press galling resistance and handleability according to claim 14, characterized in that said lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μ m, and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μ m.

16. A surface-treated metal sheet with excellent press galling resistance and handleability according to claim 14 or 15, characterized in that said aqueous organic/inorganic compound film (C) is composed of an aqueous resin and a compound lubricant prepared by combining a lubricant (A) of a polyolefin wax dispersion with a molecular weight of 6000-15,000 and a lubricant (B) of a polyolefin wax dispersion with a molecular weight of 1000-5000.

17. A surface-treated metal sheet with excellent press galling resistance and handleability according to claim 16, characterized in that said lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μ m, and modified polyolefin wax

dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm , and lubricant (B) is a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-3.0 μm .

18. A surface-treated metal sheet with excellent press galling resistance and handleability according to any one of claims 14 to 17, characterized in that the surface has a dynamic friction coefficient of 0.07-0.15 and a static friction coefficient of 0.10 or higher.

19. A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and handleability, characterized in that after coating onto a plated metal sheet an aqueous organic/inorganic compound paint (E) composed of either or both an aqueous resin and a silicate compound, as well as a lubricant (A) which is a polyolefin wax dispersion with a molecular weight of 6000-15,000 and water, to 0.05-0.3 g/m² in terms of dry weight, baking it to form a first layer, and then coating an aqueous organic/inorganic compound paint (F) composed of either or both an aqueous resin and a silicate compound, as well as colloidal silica and water wherein the colloidal silica content is 5-35 wt% in terms of solid content, to 0.5-5.0 g/m² in terms of dry weight, and baking it to form a second layer.

20. A process for manufacture of a surface-treated metal sheet with excellent press galling resistance and handleability according to claim 19, characterized in that said lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm .

21. A process for manufacture of a surface-treated

metal sheet with excellent press galling resistance and handleability according to claim 19 or 20, characterized in that said aqueous organic/inorganic compound paint (E) is composed of an aqueous resin, a compound lubricant
5 prepared by combining a lubricant (A) of a polyolefin wax dispersion with a molecular weight of 6000-15,000 and a lubricant (B) of a polyolefin wax dispersion with a molecular weight of 1000-5000, and water.

22. A process for manufacture of a surface-treated
10 metal sheet with excellent press galling resistance and handleability according to any one of claims 19 to 21, characterized in that said lubricant (A) is at least one type of lubricant selected from among polyolefin wax dispersions containing no polar groups and having a
15 molecular weight of 6000-15,000 and a particle size of 0.1-5.0 μm , and modified polyolefin wax dispersions with a molecular weight of 6000-15,000, an acid value of 40 or below and a particle size of 0.1-5.0 μm , and lubricant
20 (B) is a polyolefin wax dispersion containing no polar groups and having a molecular weight of 1000-5000 and a particle size of 0.1-3.0 μm .