

DESCRIPTION

TITLE OF THE INVENTION:

FILM-FORMING METHOD AND FILM-FORMED ARTICLE

5 TECHNICAL FIELD

[0001]

The invention relates to a method of forming a coating on a metal roof of an existing architectural structure.

10

BACKGROUND ART

[0002]

Roofs of architectural structures such as houses, factories, and warehouses have been made using a variety of materials such as clay roof tiles, cement roof tiles, slate roof tiles, asphalt shingles, and metal sheets. Among them, roof tile materials such as clay roof tiles, which have been used traditionally, are somewhat disadvantageous in terms of earthquake resistance, etc., because they have a relatively heavy weight per piece and may apply a heavy load on an architectural structure.

20

[0003]

On the other hand, metal sheet roof materials, which are significantly lighter than roof tile materials, have been recently often used in various architectural

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structures. Steel sheets with painted surfaces are generally used for such metal roofs. Unfortunately, the noise of falling rain on such metal roofs used in architectural structures tends to be higher, which is not preferred for living conditions, etc.

[0004]

For example, Japanese Patent Application Laid-Open (JP-A) No. 2000-64512 (Patent Document 1) discloses a method of reducing rain noise on a metal roof, which includes placing a heat insulator made of a synthetic resin foam, a rubber foam, or the like on the back surface (indoor side) of a metal roof. JP-A No. 2005-9205 (Patent Document 2) also discloses a method of reducing rain noise by using a damping adhesive with a specific loss factor in a metal roof structure including a metal roofing material, a damping adhesive layer, and a backing material.

[0005]

Unfortunately, if the methods disclosed in these patent documents, which are all directed to indoor side structures for metal roofs, are used for existing architectural structures, modification of attic structures and other processes will be necessary, which may lead to extensive construction.

[0006]

On the other hand, JP-A No. 2003-238897 (Patent

Document 3) discloses a method of forming a sound-insulating coating, which includes applying a paint composition for forming a soft paint film and then applying another paint composition for forming a hard paint film
5 onto the soft paint film. The technique disclosed in Patent Document 3 is applied to the outdoor side of a metal roof, which can also be performed to refurbish the metal roof at the same time.

[0007]

10 Unfortunately, in some cases, satisfactory performance cannot be obtained for rain noise reduction and other purposes only by simply stacking coating compositions for forming soft and hard paint films as disclosed in Patent Document 3.

15 [0008]

On the other hand, in recent years, there has been a move afoot to reduce power consumption for air conditioning used in buildings in view of environmental protection, energy saving, etc. To meet such a move, there are
20 proposed techniques to suppress the sunlight-induced increase in the temperature of roof materials. For example, JP-A No. 2004-10903 (Patent Document 4) discloses that a paint composition containing hollow ceramic empty particles at a high concentration is applied to a roof material.

25 [0009]

Unfortunately, a sufficient rain noise-reducing effect cannot be expected even if the paint composition as disclosed in Patent Document 4 is applied to roof materials.

5 PRIOR ART DOCUMENTS

Patent Documents

[0010]

Patent Document 1: JP-A No. 2000-64512

Patent Document 2: JP-A No. 2005-9205

10 Patent Document 3: JP-A No. 2003-238897

Patent Document 4: JP-A No. 2004-10903

SUMMARY OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

15 [0011]

An object of the invention, which has been accomplished in view of the above problems, is to provide a method that can conveniently and effectively reduce rain noise on a metal roof formed in an existing architectural structure and also suppress direct sunlight-induced temperature increase.

20

MEANS FOR SOLVING THE PROBLEMS

[0012]

25 As a result of earnest studies to solve such problems,

the inventors have accomplished the invention based on the finding that when a coating including a specific intermediate coating layer and a specific top coating layer is formed on the outdoor side surface of a metal roof of an existing architectural structure, the level of the noise of raindrops falling on the metal roof can be kept low, and the temperature increase during direct solar irradiation can also be suppressed.

[0013]

10 Thus, the invention is directed to:

1. a method of forming a coating, including:

forming an intermediate coating layer on the outdoor side surface of a metal roof of an existing architectural structure, wherein the intermediate coating layer includes a dispersion of 30 to 300 parts by weight of inorganic particles in 100 parts by weight of a resin matrix derived from a urethane prepolymer and has a thickness of 50 to 1,000 μm ; and

forming a top coating layer on the intermediate coating layer, wherein the top coating layer contains an infrared reflecting powder and/or an infrared transmitting powder, and water has a contact angle of 70° or less on the coating formed; and

2. a coating structure obtained by the coating forming method according to item 1.

EFFECTS OF THE INVENTION

[0014]

According to the invention, rain noise on a metal
5 roof formed in an existing architectural structure can be
reduced conveniently and effectively. The invention also
makes it possible to suppress the direct sunlight-induced
increase in the temperature of roof materials, so that
power consumption for air conditioning can also be reduced
10 in summer and other seasons. The method of the invention
can also refurbish a metal roof at the same time, which
also contributes to improvements in the esthetic quality of
architectural structures.

15 EMBODIMENTS FOR CARRYING OUT THE INVENTION

[0015]

Hereinafter, embodiments for carrying out the
invention will be described.

[0016]

20 The coating forming method of the invention is
performed on the outdoor side surface of a metal roof of an
existing architectural structure.

[0017]

Examples of the base material that forms the metal
25 roof include a metal sheet such as a steel sheet, a

stainless steel sheet, an aluminum sheet, an aluminum alloy sheet, or a copper sheet, and a plated metal sheet such as a zinc-aluminum-alloy-plated steel sheet such as a Galtite or Galvalume steel sheet, an aluminum-plated steel sheet,
5 or a zinc-plated steel sheet. These sheets may also be coated with various types of paint or the like. The thickness of such a base material is generally from about 0.2 to about 2 mm.

[0018]

10 The invention can bring about an advantageous effect, particularly when it is performed on a base material having an existing paint film with low lightness. The lightness (L^*) of such an existing paint film is preferably 80 or less, more preferably 60 or less. The lightness (L^*) is a
15 value in the CIE $L^*a^*b^*$ color space, which can be measured using a spectrophotometer.

[0019]

In the invention, the intermediate coating layer may be formed directly on the base material, but alternatively
20 an undercoating layer of anti-corrosive paint or the like may also be formed on the base material. In the invention, when such an undercoating layer is formed, the advantageous effects of the invention can be obtained for a long period of time. It will be understood that in the invention, such
25 an undercoating layer does not interfere with the effect of

reducing rain noise, the effect of suppressing temperature increase, or other effects.

[0020]

An anti-corrosive paint composition containing a
5 resin and an anti-corrosive pigment or the like as
essential components may be used. In such a composition,
for example, the resin may be a vinyl chloride resin, an
epoxy resin, an acrylic resin, a urethane resin, an acrylic
silicone resin, an alkyd resin, or any other resin. The
10 resin may be used in the form of a solution, a dispersion,
or a mixture of them.

[0021]

A commercially available or known material may be
used as the anti-corrosive pigment. Examples include a
15 phosphate-based anti-corrosive pigment such as zinc
phosphate, iron phosphate, or aluminum phosphate, a
phosphite-based anti-corrosive pigment such as zinc
phosphite, iron phosphite, or aluminum phosphite, a
molybdate-based anti-corrosive pigment such as calcium
20 molybdate, aluminum molybdate, or barium molybdate, a
vanadium-based anti-corrosion pigment such as vanadium
oxide, and a chromate-based anti-corrosive pigment such as
strontium chromate, zinc chromate, calcium chromate,
potassium chromate, or barium chromate. Based on 100 parts
25 by weight of the solid of the resin, the anti-corrosive

pigment may be mixed generally in an amount of 5 to 150 parts by weight, preferably about 10 to about 100 parts by weight.

[0022]

5 The undercoating layer can be formed by applying an anti-corrosive paint composition as described above and drying the composition. The application method to be used may be any appropriate coating method such as spray coating, roller coating, or brush coating. The drying may be
10 performed at normal temperature (about 0 to about 40°C). The thickness of the undercoating layer is generally from about 5 to about 200 μm , preferably from about 10 to about 100 μm .

[0023]

15 In the invention, the intermediate coating layer is formed on the base material optionally provided with the undercoating layer as described above. The intermediate coating layer is made of an intermediate coating material including a dispersion of inorganic particles in a resin
20 matrix derived from a urethane prepolymer. In the invention, the use of such a material enables an increase in the thickness, strength, and other properties of the intermediate coating layer, which is also highly effective in reducing rain noise, suppressing temperature increase,
25 and improving adhesion and other properties.

[0024]

In the intermediate coating material, the resin matrix derived from a urethane prepolymer has a continuous phase formed of a polymer containing the reaction product
5 of the urethane prepolymer. In the invention, the use of such a specific resin matrix can enhance the effect of reducing rain noise and other effects.

[0025]

For such a matrix, the urethane prepolymer, which has
10 an isocyanate group at the end of the molecule, can be obtained by reaction of a polyol compound with excess of a polyisocyanate compound.

[0026]

For example, the polyol compound used to form the
15 urethane prepolymer may be polyether polyol, polyester polyol, or the like. Such polymers generally have a weight average molecular weight of 300 to 5,000 (preferably 500 to 3,000).

[0027]

20 The polyisocyanate compound may be aliphatic, alicyclic, or aromatic polyisocyanate used in general production of polyurethane. Specific examples include tetramethylene diisocyanate, hexamethylene diisocyanate, 1,4-cyclohexane diisocyanate, 4,4'-dicyclohexylmethane
25 diisocyanate, isophorone diisocyanate, 2,4-tolylene

diisocyanate, 2,6-tolylene diisocyanate, m-xylene diisocyanate, and 4,4'-diphenylmethane diisocyanate.

[0028]

The reaction ratio between the polyol compound and the polyisocyanate compound may be set in such a manner that the isocyanate group in the polyisocyanate compound is excessive relative to the hydroxyl group in the polyol compound, and in general, it is preferably set in such a manner that NCO/OH is from about 1.2 to about 2.2.

10 [0029]

In the intermediate coating material, the resin matrix contains at least a product of reaction between the urethane prepolymer and an active hydrogen-containing compound. The active hydrogen-containing compound is a compound capable of reacting with the isocyanate group of the urethane prepolymer. Examples of such an active hydrogen-containing compound that may be used include an amino group-containing compound and a hydroxyl group-containing compound.

20 [0030]

Specific examples of the amino group-containing compound include aromatic, aliphatic, or heterocyclic polyamines, and modifications thereof, such as epoxide addition products thereof, amidation products thereof, and Mannich reaction products thereof.

[0031]

Examples of the hydroxyl-group containing compound include a polyol compound such as polyether polyol, polyester polyol, or acrylic polyol, and a hydroxyl group-
5 containing vinyl compound, a hydroxyl group-containing epoxy compound, etc. When the urethane prepolymer is allowed to react with the hydroxyl group-containing vinyl compound, the residual vinyl groups can be allowed to further react with each other. When the urethane
10 prepolymer is allowed to react with the hydroxyl group-containing epoxy compound, an amino group-containing compound or the like may be further added so that the residual epoxy group can undergo a reaction. In particular, the hydroxyl group-containing compound is preferably
15 acrylic polyol.

[0032]

Examples of the inorganic particles to be used include heavy calcium carbonate, precipitated calcium carbonate, kaolin, talc, clay, argil, china clay, barium
20 sulfate, barium carbonate, silica sand, silica stone, diatom earth, titanium oxide, zinc oxide, and aluminum oxide, one or more of which may be used. The inorganic particles preferably have an average particle size of 0.1 to 100 μm (more preferably 0.2 to 50 μm , even more
25 preferably 0.3 to 20 μm).

[0033]

The intermediate coating layer preferably contains 50% by weight or more (more preferably 70% by weight or more) of inorganic particles with an average particle size of 0.5 to 100 μm (preferably 1 to 50 μm , more preferably 2 to 20 μm) based on the total amount of the inorganic particles. Such a feature of the inorganic particles is advantageous in increasing the thickness, reducing rain noise, and suppressing temperature increase.

10 [0034]

The content of the inorganic particles in the intermediate coating layer may be from 30 to 300 parts by weight (preferably from 50 to 250 parts by weight, more preferably from 80 to 230 parts by weight) based on 100 parts by weight of the resin matrix derived from the urethane prepolymer. The content of the inorganic particles in such a range is advantageous in increasing the thickness, strength, and other properties of the intermediate coating layer, which is also sufficiently effective in reducing rain noise and increasing bonding strength.

[0035]

The use of such an intermediate coating layer can also be sufficiently effective in suppressing temperature increase. It is considered that the intermediate coating

25

layer can produce the effect of suppressing temperature increase by efficiently blocking sunlight. Although the mechanism of it remains unclear, it is considered that the intermediate coating layer can contain a relatively high content of the inorganic particles and be made relatively thick, so that the intermediate coating layer can sufficiently produce complex light-refraction effects.

[0036]

If the content of the inorganic particles in the intermediate coating layer is too low, it may be difficult to obtain a thick coating, and the coating may have insufficient strength, so that the effect of reducing rain noise or suppressing temperature increase, the adhesion, or other properties may be insufficient. If the content of the inorganic particles is too high, it may be difficult to obtain the effect of reducing rain noise sufficiently.

[0037]

Such an intermediate coating layer can be formed by applying and drying an intermediate coating material containing a urethane prepolymer, an active hydrogen-containing compound, and inorganic particles, or by applying and drying an intermediate coating material containing a product of reaction between a urethane prepolymer and a hydroxyl group-containing epoxy compound, an amino group-containing compound, and inorganic particles.

The intermediate coating material may be of an aqueous type or a solvent (organic solvent) type. Specifically, when the former type of intermediate coating material is used, the resin matrix can be formed by a process including

5 mixing the urethane prepolymer and the active hydrogen compound at the time of coating and allowing them to react in the process of forming a coating. In this type of intermediate coating material, the solid weight ratio of the urethane prepolymer to the active hydrogen compound is
10 preferably from 50/100 to 400/100, more preferably from 70/100 to 200/100, even more preferably from 90/100 to 150/100. When the latter type of intermediate coating material is used, the resin matrix can be formed by a process including mixing the amino group-containing
15 compound and the product of reaction between the urethane prepolymer and the hydrogen group-containing epoxy compound at the time of coating and allowing them to react in the process of forming a coating.

[0038]

20 The intermediate coating material may be applied using any appropriate coating method such as spray coating, roller coating, or brush coating. The drying may be performed at normal temperature.

[0039]

25 The intermediate coating layer generally has a

thickness of 50 to 1,000 μm , preferably 100 to 500 μm . If the thickness of the intermediate coating layer is less than 50 μm , it may be difficult to obtain the effect of reducing rain noise or suppressing temperature increase sufficiently. If the thickness is more than 1,000 μm , the load of the intermediate coating layer may be high, which is disadvantageous in reducing the weight load on an architectural structure.

[0040]

10 In the invention, a top coating layer is formed on the intermediate coating layer, in which the top coating layer contains an infrared reflecting powder and/or an infrared transmitting powder, and water has a contact angle of 70° or less (hereinafter also simply referred to as
15 "contact angle") on the coating formed. In the invention, the intermediate coating layer and the top coating layer are stacked so that advantageous effects such as a rain noise reducing effect and a temperature increase suppressing effect can be obtained for a long period of
20 time. In addition, the stacking of the intermediate coating layer and the top coating layer is useful to prevent rain from penetrating the metal roof or producing the effect of preventing the metal roof from making noise (reducing noise) (or suppressing temperature increase so
25 that the expansion and contraction of the metal roof can be

suppressed).

[0041]

Although the mechanism of the rain noise-reducing effect remains unclear, the factors described below are considered to contribute to the effect. Specifically, it is considered that the contact angle on the top coating layer is relatively low so that the bounce of raindrops is reduced when falling raindrops come into contact with the roof, on which the cushion properties of the intermediate coating material has a synergistic effect, so that rain noise is successfully reduced. It is considered that in the invention, the contact angle on the top coating layer is relatively low, so that during rainfall, a water film is also formed on the surface of the top coating layer to reduce the bounce of raindrops.

[0042]

As for the effect of suppressing temperature increase, it is considered that not only the effect of the intermediate coating layer described above but also the infrared reflecting powder and/or the infrared transmitting powder contained in the top coating layer contributes to the effect of suppressing heat storage into the top coating layer itself.

[0043]

The top coating layer is such that the contact angle

on it is 70° or less, preferably 60° or less, more preferably 50° or less. If the contact angle is more than 70°, it may be difficult to obtain the effect of reducing rain noise sufficiently. The contact angle of water on the coating formed is a value measured using a contact angle meter.

[0044]

Such a top coating layer can be formed by applying and drying a top coating material capable of satisfying the above requirements. Specifically, a composition containing a binder and an infrared reflecting powder and/or an infrared transmitting powder can be used as the top coating material. In addition to these components, if necessary, the top coating material may further contain any of various additives.

[0045]

In the top coating material, for example, the binder may be a resin having a hydrophilic group such as a hydroxyl group, a carboxyl group, an amino group, or an amide group, a resin having a hydrophilic segment such as polyalkylene oxide, polyoxazoline, or polyamide, or a mixture of any of various resins and a hydrophilicity-imparting component. For example, the resin to be used in the top coating material may be a vinyl acetate resin, an alkyd resin, a vinyl chloride resin, an acrylic resin, a

urethane resin, an acrylic silicone resin, a fluororesin, or a resin having a main skeleton formed of any combination thereof. Among them, one or more selected from an acrylic resin, a urethane resin, an acrylic silicone resin, and a fluororesin are particularly preferred. The resin may be in any of a water-based form and a solvent-based form.

[0046]

For example, the hydrophilicity-imparting component may be an inorganic oxide sol, an alkoxysilane compound, or the like. For example, the inorganic oxide sol may be an aluminum oxide sol, a silicon oxide sol, a zirconium oxide sol, an antimony oxide sol, or the like. The inorganic oxide sol or the alkoxysilane compound is particularly advantageous for suppressing temperature increase.

[0047]

Tetraalkoxysilane, a condensate of tetraalkoxysilane, and modifications thereof may be used as the alkoxysilane compound. The alkoxysilane compound generally has an average degree of condensation of 1 to 100, preferably about 4 to about 20.

[0048]

In the invention, the hydrophilicity-imparting component is preferably a condensate of tetraalkoxysilane having an alkoxyl group of 1 to 2 carbon atoms and an alkoxyl group of 3 to 12 carbon atoms, in which the alkoxyl

group of 3 to 12 carbon atoms preferably makes up 5 to 50% by equivalent of all alkoxyl groups of the compound. For example, the alkoxyl group of 3 to 12 carbon atoms may be a straight-chain alkoxyl group such as an n-propoxy group, an n-butoxy group, an n-pentyloxy group, an n-hexyloxy group, an n-octyloxy group, or an n-dodecyloxy group, or a branched alkoxyl group such as an isopropoxy group, an isobutoxy group, a tert-butoxy group, a sec-butoxy group, an isopentyloxy group, a neopentyloxy group, an isohexyloxy group, a 3-methylpentyloxy group, a 1-methylhexyloxy group, a 1-ethylpentyloxy group, a 2,3-dimethylbutoxy group, a 1,5-dimethylhexyloxy group, a 2-ethylhexyloxy group, a 1-methylheptyloxy group, or a tert-octyloxy group. Among them, a branched alkoxyl group is preferred. For example, such a compound can be obtained by a method of modifying a condensate of tetraalkoxysilane having an alkoxyl group of 1 to 2 carbon atoms by transesterification with an alcohol of 3 to 12 carbon atoms.

[0049]

Such a hydrophilicity-imparting component may be generally mixed in an amount of 0.1 to 50 parts by weight (preferably 0.5 to 20 parts by weight) based on 100 parts by weight of the solid of the resin to form the top coating material.

[0050]

In the top coating layer, for example, the infrared reflecting powder may be aluminum flake, titanium oxide, barium sulfate, zinc oxide, calcium carbonate, silicon oxide, magnesium oxide, zirconium oxide, yttrium oxide, indium oxide, alumina, iron-chromium complex oxide, manganese-bismuth complex oxide, or manganese-yttrium complex oxide.

[0051]

On the other hand, for example, the infrared transmitting powder may be a perylene pigment, an azo pigment, chrome yellow, red iron oxide, vermilion, titanium red, cadmium red, quinacridone red, isoindolinone, benzimidazolone, phthalocyanine green, phthalocyanine blue, cobalt blue, indanthrene blue, ultramarine, iron blue, or the like, and one or more of these materials may be used. In general, there is a limit to hues that can be produced using only an infrared reflecting powder, but coatings of various hues can be formed using an infrared reflecting powder in combination with an infrared transmitting powder as needed.

[0052]

The infrared reflecting powder and/or the infrared transmitting powder are/is preferably mixed in an amount (or total amount) of 1 to 200 parts by weight, more preferably 2 to 100 parts by weight, based on 100 parts by

weight of the solid of the resin. Such a mixed amount makes it possible to color the top coating layer as desired and to protect the intermediate coating layer. The powder in the top coating layer preferably includes only the
5 infrared reflecting powder and/or the infrared transmitting powder described above.

[0053]

In the invention, the top coating layer can be formed by applying and drying the top coating material described
10 above. Any appropriate coating method may be used, such as spray coating, roller coating, or brush coating. The drying may be performed at normal temperature. The top coating layer generally has a thickness of 200 μm or less, preferably 10 to 150 μm .

15 [0054]

In the invention, the intermediate coating layer and the top coating layer, or the undercoating layer, the intermediate coating layer, and the top coating layer are stacked in this order on the outdoor side surface of a
20 metal roof of an existing architectural structure, and the top coating layer forms the uppermost surface of the laminated film. As long as the effects of the invention are not significantly impaired, a middle layer may also be provided between the intermediate coating layer and the top
25 coating layer, if necessary.

EXAMPLES

[0055]

Hereinafter, examples and comparative examples are
5 shown to describe the features of the invention more
specifically.

[0056]

(Production of Intermediate Coating Materials)

Intermediate Coating Material 1

10 An intermediate coating material 1 was produced by
uniformly mixing 130 parts by weight of urethane-modified
epoxy resin (a glycidol adduct (70% by weight in a non-
volatile content) of isocyanate-terminated urethane
prepolymer (a product of reaction between polyether polyol
15 (1,000 in weight average molecular weight) and 2,4-tolylene
diisocyanate) with 120 parts by weight of heavy calcium
carbonate A (3 μ m in average particle size), 24 parts by
weight of a hydrocarbon-based solvent, 1 part by weight of
a silicone-based anti-foaming agent, and 9 parts by weight
20 of modified polyamine (100% by weight in solids content).

[0057]

Intermediate Coating Material 2

An intermediate coating material 2 was produced by
uniformly mixing 104 parts by weight of soluble acrylic
25 polyol A (50 KOHmg/g in hydroxyl value, 34°C in glass

transition temperature, and 46% by weight in solids content) with 110 parts by weight of heavy calcium carbonate A (3 μm in average particle size), 10 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 52 parts by weight of isocyanate-terminated urethane prepolymer A (a product (100% by weight in non-volatile content, and 3% by weight in NCO content) of reaction between polyether polyol (2,000 in weight average molecular weight) and 2,4-tolylene diisocyanate).

[0058]

Intermediate Coating Material 3

An intermediate coating material 3 was produced by uniformly mixing 104 parts by weight of soluble acrylic polyol A with 225 parts by weight of heavy calcium carbonate A, 25 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 52 parts by weight of isocyanate-terminated urethane prepolymer A.

[0059]

Intermediate Coating Material 4

An intermediate coating material 4 was produced by uniformly mixing 104 parts by weight of soluble acrylic polyol A with 95 parts by weight of heavy calcium carbonate A, 25 parts by weight of titanium oxide A (0.3 μm in

average particle size), 10 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 52 parts by weight of isocyanate-terminated urethane prepolymer A.

5 [0060]

Intermediate Coating Material 5

An intermediate coating material 5 was produced by uniformly mixing 104 parts by weight of soluble acrylic polyol A with 350 parts by weight of heavy calcium carbonate A, 40 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 52 parts by weight of isocyanate-terminated urethane prepolymer A.

[0061]

15 Intermediate Coating Material 6

An intermediate coating material 6 was produced by uniformly mixing 104 parts by weight of soluble acrylic polyol A with 15 parts by weight of heavy calcium carbonate A, 2 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 52 parts by weight of isocyanate-terminated urethane prepolymer A.

[0062]

Intermediate Coating Material 7

25 An intermediate coating material 7 was produced by

uniformly mixing 55 parts by weight of dimer acid-modified epoxy resin (70% by weight in solids content) with 120 parts by weight of heavy calcium carbonate A, 15 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 45 parts by weight of modified polyamine (100% by weight in solids content).

[0063]

Intermediate Coating Material 8

An intermediate coating material 8 was produced by uniformly mixing 96 parts by weight of soluble polyether polyol (50 KOHmg/g in hydroxyl value, and 50% by weight in solids content) with 110 parts by weight of heavy calcium carbonate A (3 μ m in average particle size), 10 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 52 parts by weight of isocyanate-terminated urethane prepolymer A (a product (100% by weight in non-volatile content, and 3% by weight in NCO content) of reaction between polyether polyol (2,000 in weight average molecular weight) and 2,4-tolylene diisocyanate).

[0064]

(Production of Top Coating Materials)

Top Coating Material 1

A top coating material 1 was produced by uniformly mixing 188 parts by weight of non-aqueous dispersion type

acrylic polyol A (50 KOHmg/g in hydroxyl value, 38°C in glass transition temperature, and 50% by weight in solids content) with 7 parts by weight of phthalocyanine green, 3 parts by weight of phthalocyanine blue, 5 parts by weight of perylene red, 4 parts by weight of benzimidazolone yellow, 23 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, 6 parts by weight of isocyanurate structure-containing polyisocyanate A (100% by weight in non-volatile content, and 21% by weight in NCO content), and 3 parts by weight of the hydrophilicity-imparting component described below.

[0065]

Hydrophilicity-Imparting Component

To 100 parts by weight of a methyl silicate condensate (1,000 in weight average molecular weight, 8 in average degree of condensation, and 100% in non-volatile content) were added 52 parts by weight of isobutyl alcohol and 0.03 parts by weight of dibutyltin dilaurate as a catalyst. They were mixed and then subjected to demethanolization at 75°C for 8 hours, so that a hydrophilicity-imparting component was obtained. In the hydrophilicity-imparting component, the equivalent ratio of the methyl group to the isobutyl group was 62:38.

[0066]

Measurement of Contact Angle

The top coating material 1 was applied to an aluminum sheet of 150 mm x 70 mm x 1 mm by spray coating so that a 40 μ m thick dry film could be formed, and dried for 7 days under normal conditions (a temperature of 23°C and a relative humidity of 50%) and then allowed to stand outdoors for 1 month. The test sheet obtained by the above method was measured for contact angle using a contact angle meter model CA-A manufactured by Kyowa Interface Science Co., Ltd. As a result, the contact angle on the top coating material 1 was 35°.

[0067]

Top Coating Material 2

A top coating material 2 was produced by uniformly mixing 188 parts by weight of non-aqueous dispersion type acrylic polyol A with 18 parts by weight of phthalocyanine green, 23 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, 6 parts by weight of isocyanurate structure-containing polyisocyanate A, and 3 parts by weight of the hydrophilicity-imparting component.

The top coating material 2 was measured for contact angle by the same method as in the case of the top coating material 1, and as a result, the contact angle on the top coating material 2 was 37°.

[0068]

Top Coating Material 3

A top coating material 3 was produced by uniformly mixing 188 parts by weight of non-aqueous dispersion type acrylic polyol A with 18 parts by weight of phthalocyanine blue, 23 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, 6 parts by weight of isocyanurate structure-containing polyisocyanate A, and 3 parts by weight of the hydrophilicity-imparting component.

The top coating material 3 was measured for contact angle by the same method as in the case of the top coating material 1, and as a result, the contact angle on the top coating material 3 was 36°.

[0069]

Top Coating Material 4

A top coating material 4 was produced by uniformly mixing 188 parts by weight of non-aqueous dispersion type acrylic polyol B (50 KOHmg/g in hydroxyl value, 32°C in glass transition temperature, and 50% by weight in solids content) with 18 parts by weight of a manganese-bismuth complex oxide, 23 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, 6 parts by weight of isocyanurate structure-containing polyisocyanate A, and 1 part by weight of the hydrophilicity-imparting component.

The top coating material 4 was measured for contact angle by the same method as in the case of the top coating material 1, and as a result, the contact angle on the top coating material 4 was 54°.

5 [0070]

Top Coating Material 5

A top coating material 5 was produced by uniformly mixing 188 parts by weight of non-aqueous dispersion type acrylic polyol B with 7 parts by weight of phthalocyanine
10 green, 3 parts by weight of phthalocyanine blue, 5 parts by weight of perylene red, 4 parts by weight of benzimidazolone yellow, 30 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, 6 parts by weight of isocyanurate
15 structure-containing polyisocyanate A, and 1 part by weight of the hydrophilicity-imparting component.

The top coating material 5 was measured for contact angle by the same method as in the case of the top coating material 1, and as a result, the contact angle on the top
20 coating material 5 was 56°.

[0071]

Top Coating Material 6

A top coating material 6 was produced by uniformly mixing 188 parts by weight of non-aqueous dispersion type
25 acrylic polyol A with 7 parts by weight of phthalocyanine

green, 3 parts by weight of phthalocyanine blue, 5 parts by weight of perylene red, 4 parts by weight of benzimidazolone yellow, 26 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 6 parts by weight of isocyanurate structure-containing polyisocyanate A.

The top coating material 6 was measured for contact angle by the same method as in the case of the top coating material 1, and as a result, the contact angle on the top coating material 6 was 83°.

[0072]

Top Coating Material 7

A top coating material 7 was produced by uniformly mixing 188 parts by weight of non-aqueous dispersion type acrylic polyol A with 18 parts by weight of carbon black, 26 parts by weight of a hydrocarbon-based solvent, 1 part by weight of a silicone-based anti-foaming agent, and 6 parts by weight of isocyanurate structure-containing polyisocyanate A.

The top coating material 7 was measured for contact angle by the same method as in the case of the top coating material 1, and as a result, the contact angle on the top coating material 7 was 82°.

[0073]

(Test Example 1)

<Noise Level Test>

An anti-corrosive undercoating material was applied by spray coating to an existing paint film-carrying aluminum sheet (300 mm x 300 mm x 1 mm, $L^*=48$) so that a 30 μm thick dry film could be formed. After the coating was dried under normal conditions for 18 hours, the intermediate coating material 1 was applied thereto by spray coating so that a 200 μm thick dry film could be formed, and then dried under normal conditions for 24 hours. Subsequently, the top coating material 1 was applied thereto by spray coating so that a 40 μm thick dry film could be formed, and dried under normal conditions for 7 days, and then allowed to stand outdoors for 1 month.

[0074]

The test sheet obtained by the above method was horizontally placed, and water was continuously scattered for 1 minute on the sheet from 3 m above using a shower nozzle. During this period, the noise level was measured using a sound level meter, which was placed 10 cm apart from the back surface of the test sheet. The noise level was evaluated according to the criteria below.

A: less than 80 dB

B: from 80 dB to less than 85 dB

C: from 85 dB to less than 90 dB

D: 90 dB or more

[0075]

<Adhesion Test>

A test sheet was prepared by the same procedure as in the case of the "noise level test" (except that an aluminum sheet of 150 mm x 70 mm x 1 mm was used instead).

[0076]

The test sheet obtained by the above method was immersed in warm water at 50°C for 72 hours and then evaluated for adhesion by the cross-cut tape method according to JIS K 5600-5-6. The evaluation criteria were as follows.

A: The lost area was less than 5%.

B: The lost area was from 5% to less than 15%.

C: The lost area was 15% or more.

15 [0077]

<Temperature Increase Suppression Test>

A test sheet was prepared by the same procedure as in the case of the "noise level test".

[0078]

20 The test sheet obtained by the above method was irradiated with an infrared ray lamp at a distance of 20 cm, and the temperature of the back surface of the test sheet was measured at the time when the increase in temperature reached equilibrium. The evaluation criteria were as follows.

25

A: The temperature of the back surface of the test sheet was less than 65°C.

B: The temperature of the back surface of the test sheet was from 65°C to less than 70°C.

5 C: The temperature of the back surface of the test sheet was from 70°C to less than 75°C.

D: The temperature of the back surface of the test sheet was 75°C or more.

[0079]

10 <Noise Level Test after Accelerated Degradation>

Test sheets were prepared by the same procedure as in the case of the "noise level test" (except that two pieces of aluminum sheet of 300 mm x 150 mm x 1 mm were used instead in each case).

15 [0080]

The test sheets obtained by the above method were exposed in an accelerated weathering machine (METAL WEATHER, manufactured by DAIPLA WINTES Co., LTD.) for 240 hours and then measured for noise level by the same method as in the
20 case of the "noise level test". This test was performed with respect to Test Examples 2 and 18.

[0081]

The test results are shown in Table 1. In Test Example 1, good results were obtained in all tests.

[0082]

[Table 1]

Coating materials used	Test Example 1	Test Example 2	Test Example 3	Test Example 4	Test Example 5	Test Example 6	Test Example 7	Test Example 8
	Intermediate coating material 1	Intermediate coating material 2	Intermediate coating material 3	Intermediate coating material 4	Intermediate coating material 4	Intermediate coating material 4	Intermediate coating material 4	Intermediate coating material 4
	Top coating material 1	Top coating material 1	Top coating material 1	Top coating material 1	Top coating material 2	Top coating material 3	Top coating material 4	Top coating material 5
Test results	Noise level	A	A	A	A	A	A	A
	Adhesion	A	A	A	A	A	A	A
	Temperature increase suppression	A	A	A	A	A	A	A
	Noise level after accelerated degradation	-	A	-	-	-	-	-

[0083]

(Test Examples 2 to 8)

Test sheets were prepared by the same method as in Test Example 1, except that the intermediate coating materials and the top coating materials shown in Table 1 were used instead, and each test was performed. The results are shown in Table 1. In Test Examples 2 to 8, good results were obtained in all tests.

[0084]

10 (Test Examples 9 to 11)

Test sheets were prepared by the same method as in Test Example 1, except that the intermediate coating materials and the top coating materials shown in Table 2 were used instead, and each test was performed. The results are shown in Table 2. In Test Examples 9 to 11, satisfactory results were not obtained in contrast to Test Examples 1 to 8.

[0085]

(Test Example 12)

20 Test sheets were prepared by the same method as in Test Example 1, except that after the anti-corrosive undercoating material was applied, the top coating material 1 was applied directly onto the undercoating, and each test was performed. The results are shown in Table 2. In Test
25 Example 12, satisfactory results were not obtained.

[0086]

(Test Example 13)

Test sheets were prepared by the same method as in Test Example 1, except that after the anti-corrosive
5 undercoating material was applied, the top coating material
5 was applied directly onto the undercoating, and each test
was performed. The results are shown in Table 2. In Test
Example 13, satisfactory results were not obtained.

[0087]

10 (Test Examples 14 to 16)

Test sheets were prepared by the same method as in Test Example 1, except that the intermediate coating materials and the top coating materials shown in Table 2
were used instead, and each test was performed. The
15 results are shown in Table 2. In Test Examples 14 to 16,
satisfactory results were not obtained.

[0088]

(Test Example 17)

Test sheets were prepared by the same method as in
20 Test Example 1, except that the intermediate coating
material and the top coating material shown in Table 2 were
used instead and that the intermediate coating material was
applied so that a 30 μm thick dry film could be formed, and
each test was performed. The results are shown in Table 2.
25 In Test Example 17, satisfactory results were not obtained.

[0089]

(Test Example 18)

Test sheets were prepared by the same method as in
Test Example 1, except that the intermediate coating
5 material and the top coating material shown in Table 2 were
used instead, and each test was performed. The results are
shown in Table 2. The result of the noise level test after
accelerated degradation was better in Test Example 2 than
in Test Example 18.

[0090]

[Table 2]

Coating Materials used	Test Example 9	Test Example 10	Test Example 11	Test Example 12	Test Example 13	Test Example 14	Test Example 15	Test Example 16	Test Example 17	Test Example 18
	Intermediate coating material 5	Intermediate coating material 6	Intermediate coating material 7	-	-	Intermediate coating material 1	Intermediate coating material 2	Intermediate coating material 4	Intermediate coating material 2	Intermediate coating material 8
Top coating material	Top coating material 1	Top coating material 1	Top coating material 1	Top coating material 1	Top coating material 5	Top coating material 6	Top coating material 6	Top coating material 7	Top coating material 1	Top coating material 1
Noise level	B	B	B	C	D	C	C	C	C	A
Adhesion	A	C	A	A	A	A	A	A	A	A
Temperature increase suppression	A	B	A	B	B	B	B	D	B	A
Noise level after accelerated degradation	-	-	-	-	-	-	-	-	-	B

CLAIMS

1. A method of forming a coating, comprising:

forming an intermediate coating layer on an outdoor
5 side surface of a metal roof of an existing architectural
structure, wherein the intermediate coating layer comprises
a dispersion of 30 to 300 parts by weight of inorganic
particles in 100 parts by weight of a resin matrix derived
from a urethane prepolymer and has a thickness of 50 to
10 1,000 μm ; and

forming a top coating layer on the intermediate
coating layer, wherein the top coating layer contains an
infrared reflecting powder and/or an infrared transmitting
powder, and water has a contact angle of 70° or less on the
15 coating formed.

2. A coating structure obtained by the coating
forming method according to claim 1.