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(54) **Titre : COMPOSITION DE PEINTURE COMPRENANT UN ELEMENT LIANT, UN PREMIER AGENT RHEOLOGIQUE ET UN DEUXIEME AGENT RHEOLOGIQUE**
(54) **Title: PAINT COMPOSITION COMPRISING A BINDER COMPONENT, A FIRST RHEOLOGY CONTROL AGENT AND A SECOND RHEOLOGY CONTROL AGENT**

(57) **Abrégé/Abstract:**

A paint composition contains (A) a binder component, (B) a first rheology control agent, and (C) a second rheology control agent, wherein the first rheology control agent (B) contains a reaction product of (b1) a polyisocyanate compound, (b2) a primary monoamine having a number average molecular weight of 300 or less, and (b3) a polyether amine having a number average molecular weight of more than 300 and less than 6000; the proportion of the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) is 0.5 mass% or more and less than 10 mass% based on the total amount of the components (b1) to (b3); the second rheology control agent(C) contains a reaction product of (c1) a polyisocyanate compound, (c2) a primary monoamine having a number average molecular weight of 300 or less, and (c3) a polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000; and the proportion of the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) is within a range of 10 to 30 mass% based on the total amount of the components (c1) to (c3).

ABSTRACT

A paint composition contains (A) a binder component, (B) a first rheology control agent, and (C) a second rheology control agent, wherein the first rheology control agent (B) contains a reaction product of (b1) a polyisocyanate compound, (b2) a primary monoamine having a number average molecular weight of 300 or less, and (b3) a polyether amine having a number average molecular weight of more than 300 and less than 6000; the proportion of the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) is 0.5 mass% or more and less than 10 mass% based on the total amount of the components (b1) to (b3); the second rheology control agent (C) contains a reaction product of (c1) a polyisocyanate compound, (c2) a primary monoamine having a number average molecular weight of 300 or less, and (c3) a polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000; and the proportion of the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) is within a range of 10 to 30 mass% based on the total amount of the components (c1) to (c3).

DESCRIPTION

Title of Invention: PAINT COMPOSITION COMPRISING A BINDER COMPONENT, A FIRST RHEOLOGY CONTROL AGENT AND A SECOND RHEOLOGY CONTROL AGENT

Technical Field

[0001]

The present invention relates to a paint composition.

Background Art

[0002]

To impart excellent appearance and properties to a substrate, a coating film is conventionally formed on the substrate by applying a paint composition to the substrate to form a wet coating film and curing the wet coating film.

[0003]

However, when the substrate has a vertical plane, the wet coating film on the vertical plane sags, making the appearance of the resulting coating film poor. To solve this problem, research has been conducted on a paint composition containing a rheology control agent (rheology controller) with a sag-control capability.

[0004]

For example, PTL 1 discloses a paint composition containing a binder component and a rheology control agent; and the rheology control agent for use contains a reaction product of a polyisocyanate compound, a primary monoamine having a number average molecular weight of 300 or less, and a polyether amine having a number average molecular weight of more than 300 and less than 6000.

Citation List

Patent Literature

[0005]

PTL 1: W02018/012552A

Summary of Invention

Technical Problem

[0006]

The coating film formed from the paint composition disclosed in PTL 1 is excellent in transparency, water resistance, and finished appearance. However, there is room for further improvement in sag resistance during coating and finished appearance and water blushing resistance of the resulting coating film.

[0007]

The present invention was made in view of the current status mentioned above. An object of the present invention is to provide a paint composition excellent in sag resistance during coating and finished appearance and resistance to blushing with water, referred to as water blushing resistance hereinafter, of the resulting coating film.

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Solution to Problem

[0008]

The present inventors conducted extensive research to achieve the object, and found that a paint composition containing a predetermined first rheology control agent and a predetermined second rheology control agent in combination can achieve the object.

[0009]

Specifically, the present invention includes the following subject matter.

[0010]

In an embodiment, provided is a paint composition comprising

(A) a binder component,
(B) a first rheology control agent, and
(C) a second rheology control agent,

wherein

the first rheology control agent (B) contains a reaction product of (b1) a polyisocyanate compound, (b2) a primary monoamine having a number average molecular weight of 300 or less, and (b3) a polyether amine having a number average molecular weight of more than 300 and less than 6000,

the proportion of the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) is 0.5 mass% or more and less than 10 mass% based on the total amount of the components (b1) to (b3),

the second rheology control agent (C) contains a reaction product of (c1) a polyisocyanate compound, (c2) a primary monoamine having a number average molecular weight of 300 or less, and (c3) a polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000,

the proportion of the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) is within a range of 10 to 30 mass% based on the total amount of the components (c1) to (c3).

[0011]

In another embodiment, the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) has three or more amino groups.

[0012]

In another embodiment, the proportion of the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) is more than 15 mass% and 30 mass% or less based on the total amount of the components (c1) to (c3).

[0013]

In another embodiment, the binder component (A) contains a hydroxy-containing resin (A1) and a crosslinking agent (A2).

[0014]

In another embodiment, the content of the first rheology control agent (B) is within a range of 0.1 to 2 parts by mass, per 100 parts by mass of the solids content of the binder component (A), and the content of the second rheology control agent (C) is within a range of 0.1 to 2 parts by mass, per 100 parts by mass of the solids content of the binder component (A).

Advantageous Effects of Invention

[0015]

The paint composition of the present invention forms a coating film excellent in sag resistance during coating, and finished appearance and water blushing resistance of the resulting coating film.

Description of Embodiments

[0016]

The paint composition of the present invention is described below in more detail.

[0017]

Binder component (A)

The binder component (A) itself has film-forming properties. The binder component (A) may be either non-crosslinkable or crosslinkable; in particular, the binder component (A) is preferably crosslinkable. As the binder component (A), a known film-forming resin that has been used as a binder component for paint can be used.

[0018]

Examples of film-forming resins include acrylic resins, polyester resins, alkyd resins, polyurethane resins, and the like. The film-forming resin preferably contains a crosslinkable functional group, such as hydroxy, carboxy, or epoxy.

[0019]

In addition to the film-forming resin, a crosslinking agent can also be used as the binder component (A). When a crosslinking agent is used as a part of the binder component (A), a resin (a base resin) that contains a crosslinkable functional group, such as hydroxy, carboxy, or epoxy, and that can form a crosslinked coating film by reaction with the crosslinking agent, can be generally used as the film-forming resin. From the viewpoint of, for example, the water resistance of the resulting coating film, the paint composition of the present invention is preferably a crosslinkable paint containing the base resin and the crosslinking agent.

[0020]

In particular, the paint composition of the present invention preferably contains a hydroxy-containing resin (A1) as at least a part of the base resin, and a crosslinking agent (A2) reactive with the hydroxy-containing resin as at least a part of the crosslinking agent.

[0021]

Hydroxy-containing resin (A1)

The hydroxy-containing resin (A1) is a resin having at least one hydroxy group per molecule. Various known resins can be used as the hydroxy-containing resin (A1). Examples include hydroxy-containing acrylic resins, hydroxy-containing polyester resins, hydroxy-containing acrylic-modified polyester resins, hydroxy-containing polyether resins, hydroxy-containing polycarbonate resins, hydroxy-containing polyurethane resins, hydroxy-containing epoxy resins, hydroxy-containing alkyd resins, and like resins. These may be used singly, or in a combination of two or more. In particular, from the viewpoint of, for example, the water resistance of the resulting coating film, the hydroxy-containing resin (A1) is preferably a hydroxy-containing acrylic resin (A1-1).

[0022]

Hydroxy-containing acrylic resin (A1-1)

The hydroxy-containing acrylic resin (A1-1) can be obtained, for example, by copolymerizing a hydroxy-containing polymerizable unsaturated monomer and another polymerizable unsaturated monomer (a polymerizable unsaturated monomer other than the hydroxy-containing polymerizable unsaturated monomer).

[0023]

The hydroxy-containing polymerizable unsaturated monomer is a compound containing one or more hydroxy groups and one or more polymerizable unsaturated bonds per molecule. Examples of hydroxy-containing polymerizable unsaturated monomers include monoesterified products of (meth)acrylic acid with a dihydric alcohol having 2 to 8 carbon atoms (e.g., 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 3-hydroxypropyl (meth)acrylate, and 4-hydroxybutyl (meth)acrylate); ε-caprolactone-modified products of such monoesterified products of (meth)acrylic acid with a dihydric alcohol having 2 to 8 carbon atoms; adducts of (meth)acrylic acid with an epoxy-containing compound (e.g., Cardura E10P, trade name, produced by Momentive Specialty Chemicals Inc., neodecanoic acid glycidyl ester); N-hydroxymethyl (meth)acrylamide; allyl alcohol; (meth)acrylates that include a hydroxy-terminated polyoxyethylene chain; and the like.

[0024]

As another polymerizable unsaturated monomer copolymerizable with the hydroxy-containing polymerizable unsaturated monomer, for example, the monomers listed in (1) to (6) below can be used. These polymerizable unsaturated monomers may be used singly, or in a combination of two or more.

[0025]

(1) Acid group-containing polymerizable unsaturated monomers

An acid group-containing polymerizable unsaturated monomer is a compound having one or more acid groups and one or more polymerizable unsaturated bonds per molecule. Examples of the monomer include carboxy-containing monomers, such as (meth)acrylic acid, crotonic acid, itaconic acid, maleic acid, and maleic anhydride; sulfonic acid-containing monomers, such as vinyl sulfonic acid and 2-sulfoethyl (meth)acrylate; acidic phosphate monomers, such as 2-(meth)acryloyloxyethyl acid phosphate, 2-(meth)acryloyloxypropyl acid phosphate, 2-

(meth)acryloyloxy-3-chloropropyl acid phosphate, and 2-methacryloyloxyethylphenyl phosphoric acid. These monomers may be used singly, or in a combination of two or more. When an acid group-containing polymerizable unsaturated monomer is used, the monomer is preferably used in such an amount that the hydroxy-containing acrylic resin (A1-1) has an acid value of 0.5 to 15 mg KOH/g, and more preferably 1 to 10 mg KOH/g.

[0026]

(2) Esterified products of acrylic acid or methacrylic acid with a monohydric alcohol having 1 to 20 carbon atoms

Specific examples include methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, n-butyl (meth)acrylate, iso-butyl (meth)acrylate, tert-butyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, isooctyl (meth)acrylate, isomyristyl (meth)acrylate, stearyl (meth)acrylate, Isostearyl Acrylate (trade name, produced by Osaka Organic Chemical Industry, Ltd.), lauryl (meth)acrylate, tridecyl (meth)acrylate, tetrahydrofurfuryl (meth)acrylate, cyclohexyl (meth)acrylate, isobornyl (meth)acrylate, and the like.

[0027]

(3) Aromatic vinyl monomers

Specific examples include styrene, α-methylstyrene, vinyltoluene, and the like.

[0028]

When an aromatic vinyl monomer is used as a constituent component, the glass transition temperature of the resulting resin is raised, and a hydrophobic coating film with a high refractive index can be obtained. This provides an effect of improving the finished appearance due to increased gloss of the coating film.

[0029]

When an aromatic vinyl monomer is used as a constituent component, its proportion is preferably within the range of 3 to 50 mass%, and in particular more preferably 5 to 40 mass%, based on the total amount of the monomer components.

[0030]

(4) Glycidyl group-containing polymerizable unsaturated monomers

A glycidyl group-containing polymerizable unsaturated monomer is a compound having one or more glycidyl groups and one or more polymerizable unsaturated bonds per molecule. Specific examples include glycidyl acrylate, glycidyl methacrylate, and the like.

[0031]

(5) Compounds containing nitrogen and a polymerizable unsaturated bond

Examples include (meth)acrylamide, N,N-dimethyl(meth)acrylamide, N-[3-(dimethylamino)propyl](meth)acrylamide, N-butoxymethyl(meth)acrylamide, diacetone(meth)acrylamide, N,N-dimethylaminoethyl(meth)acrylate, vinylpyridine, vinylimidazole, acrylonitrile, methacrylonitrile, and the like.

[0032]

(6) Other vinyl compounds

Examples include vinyl acetate, vinyl propionate, vinyl chloride, vinyl versatates, and the like. Examples of vinyl versatates include the commercially available products VEOVA 9 and VEOVA 10 (trade names, produced by Japan Epoxy Resin Co., Ltd.), and the like.

[0033]

As other polymerizable unsaturated monomers, those listed in (1) to (6) above may be used singly, or in a combination of two or more.

[0034]

The term "polymerizable unsaturated monomer" as used herein refers to a monomer having one or more (e.g., one to four) polymerizable unsaturated groups. The polymerizable unsaturated group refers to an unsaturated group that can undergo radical polymerization. Examples of the polymerizable unsaturated group include a vinyl group, a (meth)acryloyl group, a (meth)acrylamide group, a vinyl ether group, an allyl group, a propenyl group, an isopropenyl group, a maleimide group, and the like.

[0035]

The term "(meth)acrylate" as used herein means acrylate or methacrylate. The term "(meth)acrylic acid" means acrylic acid or methacrylic acid. The term "(meth)acryloyl" means acryloyl or methacryloyl. The term "(meth)acrylamide" means acrylamide or methacrylamide.

[0036]

From the viewpoint of the curability and water resistance, the hydroxy-containing acrylic resin (A1-1) preferably has a hydroxy value of 70 to 200 mg KOH/g, more preferably 80 to 185 mg KOH/g, and even more preferably 100 to 170 mg KOH/g.

[0037]

From the viewpoint of the finished appearance and curability of the coating film, the hydroxy-containing acrylic resin (A1-1) preferably has a weight average molecular weight of 2000 to 50000, more preferably 3000 to 30000, and even more preferably 4000 to 10000.

[0038]

In the present specification, the average molecular weight refers to a value calculated from a chromatogram measured by gel permeation chromatography based on the molecular weight of standard polystyrene. For the gel permeation chromatography, HLC8120GPC (produced by Tosoh Corporation) was used. The measurement was conducted using four columns: TSKgel G-4000HXL, TSKgel G-3000HXL, TSKgel G-2500HXL, and TSKgel G-2000HXL (trade names, all produced by Tosoh Corporation) under the conditions of mobile phase: tetrahydrofuran; measuring temperature: 40°C; flow rate: 1 cc/min; and detector: RI.

[0039]

The glass transition temperature of the hydroxy-containing acrylic resin (A1-1) is preferably within the range of -50 to 60°C, more preferably 10 to 50°C, and even more preferably 20 to 45°C, from the viewpoint of the hardness and finished appearance of the coating film.

[0040]

In the present specification, the glass transition temperature (°C) of the acrylic resin was calculated using the following formulae.

[0041]

$1/Tg\ (K) = (W1/T1) + (W2/T2) + \ldots\ldots \quad (1)$

$Tg\ (^\circ C) = Tg\ (K) - 273 \quad (2)$

In each formula, W1, W2, ... represent the mass fractions of the monomers used for copolymerization, and T1, T2, ... represent the Tg (K) of homopolymers of each of the monomers.

T1, T2, ... are the values disclosed in the Polymer Handbook (Second Edition, J. Brandrup and E.H. Immergut ed.), III-139 to 179. When the Tg of the homopolymer of a monomer is unclear, the glass transition temperature (°C) refers to a static glass transition temperature. For example, a sample is taken in a measuring cup and subjected to vacuum-suction to completely remove the solvent, followed by measurement of changes in the quantity of heat at a heating rate of 3°C/min in a temperature range of -20 to +200°C using a DSC-220U differential scanning calorimeter (produced by Seiko Instruments Inc.). The initial change point in the baseline at the low-temperature side is considered to be the static glass transition temperature.

[0042]

The hydroxy-containing acrylic resin (A1-1) preferably has an acid value of 0.5 to 15 mg KOH/g, and more preferably 1 to 10 mg KOH/g, from the viewpoint of, for example, the pot life of the paint composition and the finished appearance.

[0043]

The method for copolymerizing the monomer mixture to obtain the hydroxy-containing acrylic resin (A1-1) is not particularly limited, and known copolymerization methods can be used. Among those, a solution polymerization method, in which polymerization is conducted in an organic solvent in the presence of a polymerization initiator, is preferably used.

[0044]

Examples of organic solvents used in the solution polymerization method include toluene, xylene, Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an oil-based high-boiling-point solvent), and like aromatic solvents; ethyl acetate, butyl acetate, propyl propionate, butyl propionate, 1-methoxy-2-propyl acetate, 2-ethoxyethyl propionate, 3-methoxybutyl acetate, ethylene glycol ethyl ether acetate, propylene glycol methyl ether acetate, and like ester-based solvents; methyl ethyl ketone, methyl isobutyl ketone, methyl amyl ketone, and like ketone-based solvents; isopropanol, n-butanol, iso-butanol, 2-ethylhexanol, and like alcohol-based solvents; and the like.

[0045]

These organic solvents may be used singly, or in a combination of two or more. From the viewpoint of the solubility of the acrylic resin, ester-based solvents and ketone-based solvents are preferable. Further, an aromatic solvent may be suitably used in combination.

[0046]

Examples of polymerization initiators used for copolymerizing the hydroxy-containing acrylic resin (A1-1) include known radical polymerization initiators, such as 2,2′-azobisisobutyronitrile, benzoyl peroxide, di-t-butyl peroxide, di-t-amyl peroxide, t-butyl peroctoate, 2,2′-azobis(2-methylbutyronitrile), and 2,2′-azobis(2,4-dimethylvaleronitrile).

[0047]

The hydroxy-containing acrylic resins (A1-1) may be used singly, or in a combination of two or more.

[0048]

Secondary hydroxy-containing acrylic resin (A1-1a)

From the viewpoint of the finished appearance of the resulting coating film, a secondary hydroxy-containing acrylic resin (A1-1a) can also be suitably used as one of the embodiments of the hydroxy-containing acrylic resin (A1-1).

[0049]

The secondary hydroxy-containing acrylic resin (A1-1a) can be produced, for example, by using a secondary hydroxy-containing polymerizable unsaturated monomer as one type of the hydroxy-containing polymerizable unsaturated monomer described above in the method for producing the hydroxy-containing acrylic resin (A1-1).

[0050]

Examples of the secondary hydroxy-containing polymerizable unsaturated monomer include polymerizable unsaturated monomers having a secondary hydroxy group whose alkyl group in the ester moiety has 2 to 8, preferably 3 to 6, and more preferably 3 or 4 carbon atoms, such as 2-hydroxypropyl (meth)acrylate, 2-hydroxybutyl (meth)acrylate, and 3-hydroxybutyl (meth)acrylate; adducts of (meth)acrylic acid with an epoxy-containing compound (e.g., Cardura E10P (trade name, produced by Momentive Specialty Chemicals Inc., neodecanoic acid glycidyl ester); and the like. These may be used singly, or in a combination of two or more. From the viewpoint of the finished appearance of the resulting coating film, 2-hydroxypropyl (meth)acrylate is preferably used.

[0051]

When the secondary hydroxy-containing polymerizable unsaturated monomer described above is used in producing the secondary hydroxy-containing acrylic resin (A1-1a), the amount of the secondary hydroxy-containing polymerizable unsaturated monomer is preferably within the range of 15 to 45 mass%, and more preferably 20 to 40 mass%, based on the total amount of the copolymerizable monomer components that constitute the secondary hydroxy-containing acrylic resin (A1-1a), from the viewpoint of the finished appearance of the resulting coating film.

[0052]

In the secondary hydroxy-containing acrylic resin (A1-1a), the content of the secondary hydroxy-containing polymerizable unsaturated monomer in the total amount of the hydroxy-containing polymerizable unsaturated monomer is within the range of preferably 50 to 100 mass%, more preferably 55 to 100 mass%, and still more preferably 60 to 100 mass%, from the viewpoint of the water resistance and finished appearance of the resulting coating film.

[0053]

Hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b)

As another embodiment of the hydroxy-containing acrylic resin (A1-1), a hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) can be preferably used from the viewpoint of scratch resistance of the resulting coating film.

[0054]

The hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) is a resin having at least one hydroxy group and at least one alkoxysilyl group per molecule.

[0055]

The use of the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) forms a crosslinkage due to a condensation reaction between alkoxysilyl groups and a reaction between an alkoxysilyl group and a hydroxyl group, thus increasing the curability of the coating film.

[0056]

Examples of the alkoxy moiety of the alkoxysilyl group present in the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) include an alkoxy moiety having about 1 to 6 carbon atoms, preferably about 1 to 3 carbon atoms, such as methoxy, ethoxy, and propoxy. The alkoxy moiety is more preferably methoxy and ethoxy, and particularly preferably methoxy from the viewpoint of scratch resistance of the resulting coating film.

[0057]

The alkoxysilyl group include a trialkoxysilyl group, a dialkoxysilyl group, and a monoalkoxysilyl group. The alkoxysilyl group is preferably a trialkoxysilyl group from the viewpoint of scratch resistance of the resulting coating film.

[0058]

When the alkoxysilyl group is a dialkoxysilyl group or a monoalkoxysilyl group, the groups other than the alkoxy that binds to the silicon atom include alkyl having about 1 to 6 carbon atoms, preferably about 1 to 3 carbon atoms (e.g., methyl, ethyl, and propyl).

[0059]

The hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) can be obtained, for example, by using an alkoxysilyl-containing polymerizable unsaturated monomer as one type of the polymerizable unsaturated monomer and other polymerizable unsaturated monomers in the method for producing the hydroxy-containing acrylic resin (A1-1).

[0060]

The alkoxysilyl-containing polymerizable unsaturated monomer is a compound having at least one alkoxysilyl group and at least one polymerizable unsaturated bond per molecule. Examples of alkoxysilyl-containing polymerizable unsaturated monomers include vinyltrimethoxysilane, vinyltriethoxysilane, acryloxyethyltrimethoxysilane, methacryloxyethyltrimethoxysilane, acryloxypropyltrimethoxysilane methacryloxypropyltrimethoxysilane, acryloxypropyltriethoxysilane, methacryloxypropyltriethoxysilane, and vinyltris(β-methoxyethoxy)silane.

[0061]

The alkoxysilyl-containing polymerizable unsaturated monomer is preferably vinyltrimethoxysilane, γ-acryloxypropyltrimethoxysilane, and γ-methacryloxypropyltrimethoxysilane, and more preferably γ-methacryloxypropyltrimethoxysilane from the viewpoint of scratch resistance of the resulting coating film.

[0062]

The alkoxysilyl-containing polymerizable unsaturated monomer for use may be a commercially available product. Examples include KBM-1003, KBE-1003, KBM-502, KBM-503, KBE-502, KBE-503, KBM-5103, and KBM-5803 (all produced by Shin-Etsu Chemical Co., Ltd.); Y-9936 and A-174 (produced by Momentive Performance

Materials Inc.); and OFS-6030 and Z-6033 (produced by Dow Toray Co., Ltd.).

[0063]

These alkoxysilyl-containing polymerizable unsaturated monomers can be used singly, or in combination of two or more.

[0064]

Specifically, the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) can be obtained, for example, by copolymerizing the hydroxy-containing polymerizable unsaturated monomer, the alkoxysilyl-containing polymerizable unsaturated monomer, and other polymerizable unsaturated monomers (polymerizable unsaturated monomers other than the hydroxy-containing polymerizable unsaturated monomer and alkoxysilyl-containing polymerizable unsaturated monomer). The other polymerizable unsaturated monomers that can be used in copolymerization are, for example, other polymerizable unsaturated monomers (1) to (6) for use in obtaining the hydroxy-containing acrylic resin (A1-1). The polymerizable unsaturated monomers can be used singly, or in combination of two or more.

[0065]

In producing the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b), the amount of the hydroxy-containing polymerizable unsaturated monomer for use is preferably within the range of 5 to 60 mass%, more preferably 15 to 50 mass%, and still more preferably 25 to 45 mass%, based on the total amount of the copolymerizable monomer components that constitute the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) from the viewpoint of scratch resistance, water resistance, curability, and finished appearance of the resulting coating film.

[0066]

The hydroxy value of the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) is preferably within the range of 70 to 200 mg KOH/g, more preferably 80 to 190 mg KOH/g, and still more preferably 100 to 180 mg KOH/g from the viewpoint of scratch resistance, water resistance, curability, and finished appearance of the resulting coating film.

[0067]

Secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c)

As another embodiment of the hydroxy-containing acrylic resin (A1-1), a secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c) can be used from the viewpoint of finished appearance and scratch resistance of the resulting coating film.

[0068]

The secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c) is included in the secondary hydroxy-containing acrylic resin (A1-1a), and also in the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b).

[0069]

The secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c) can be produced, for example, by using a secondary hydroxy-containing polymerizable unsaturated monomer (e.g., a secondary hydroxy-containing polymerizable unsaturated monomer usable in the production of the secondary hydroxy-containing acrylic resin (A1-1a)) as one type of the hydroxy-containing polymerizable unsaturated monomer in the method for producing the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b).

[0070]

When the secondary hydroxy-containing polymerizable unsaturated monomer described above is used in the production of the secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c), the amount of the secondary hydroxy-containing polymerizable unsaturated monomer for use is preferably within the range of 15 to 45 mass%, and more preferably 20 to 40 mass% based on the total amount of the copolymerizable monomer components that constitute the secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c) from the viewpoint of finished appearance of the resulting coating film.

[0071]

In the production of the secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c), the content of the secondary hydroxy-containing polymerizable unsaturated monomer in the total amount of the hydroxy-containing polymerizable unsaturated monomer is preferably within the range of 50 to 100 mass%, more preferably 55 to 100 mass%, and still more preferably 60 to 100 mass% from the viewpoint of water resistance and finished appearance of the resulting coating film.

[0072]

Examples of film-forming resins usable as the binder component (A) other than those described above in the paint composition of the present invention include hydroxy-free acrylic resin, hydroxy-containing or hydroxy-free polyester resin, hydroxy-containing or hydroxy-free polyether resin, and hydroxy-containing or hydroxy-free polyurethane resin. Of these, hydroxy-containing polyester resin and hydroxy-containing polyurethane resin are preferable as a film-forming resin.

[0073]

The hydroxy-containing polyester resin can be produced by a commonly used method, such as esterification between a polybasic acid and a polyhydric alcohol. The polybasic acid is a compound having two or more carboxyl groups per molecule, such as phthalic acid, isophthalic acid, terephthalic acid, succinic acid, adipic acid, azelaic acid, sebacic acid, tetrahydrophthalic acid, hexahydrophthalic acid, maleic acid, fumaric acid, itaconic acid, trimellitic acid, pyromellitic acid, and anhydrides thereof. The polyhydric alcohol is a compound having two or more hydroxyl groups per molecule, and examples include diols, such as ethylene glycol, propylene glycol, 1,3-propanediol, 1,4-butanediol, 1,5-pentanediol, 1,6-hexanediol, 2,2-diethyl-1,3-propanediol, neopentylglycol, 1,9-nonanediol, 1,4-cyclohexanediol, hydroxypivalic acid neopentyl glycol ester, 2-butyl-2-ethyl-1,3-propanediol, 3-methyl-1,5-pentanediol, 2,2,4-trimethylpentanediol, and hydrogenated bisphenol A; trihydric or higher polyol components, such as trimethylolpropane, trimethylolethane, glycerin, and pentaerythritol; and hydroxycarboxylic acids, such as 2,2-dimethylolpropionic acid, 2,2-dimethylolbutanoic acid, 2,2-dimethylolpentanoic acid, 2,2-dimethylolhexanoic acid, and 2,2-dimethyloloctanoic acid.

[0074]

An α-olefin epoxide, such as propylene oxide and butylene oxide, or a monoepoxy compound, such as Cardura E10P (trade name, produced by Momentive Specialty Chemicals, a glycidyl ester of a synthetic highly branched saturated fatty acid), may be reacted with an acid to introduce these compounds into a polyester resin.

[0075]

The introduction of carboxyl groups into a polyester resin can be performed, for example, by adding an acid anhydride to a hydroxy-containing polyester, and half-esterifying the hydroxy-containing polyester.

[0076]

The hydroxy value of the hydroxy-containing polyester resin is preferably within the range of 80 to 250 mg KOH/g, and more preferably 100 to 200 mg KOH/g. The weight average molecular weight of the hydroxy-containing polyester resin is preferably within the range of 500 to 3500, and more preferably 500 to 2500.

[0077]

The hydroxy-containing polyurethane resin is, for example, a hydroxy-containing polyurethane resin obtained by reacting a polyol with a polyisocyanate.

[0078]

Examples of low-molecular weight polyols include dihydric alcohols, such as ethylene glycol, diethylene glycol, propylene glycol, butylene glycol, and hexamethylene glycol; and trihydric alcohols, such as trimethylol propane, glycerin, and pentaerythritol. Examples of high-molecular weight polyols include polyether polyols, polyester polyols, acrylic polyols, and epoxy polyols. Examples of polyether polyols include polyethylene glycol, polypropylene glycol, and polytetramethylene glycol. Examples of polyester polyols include the dihydric alcohols described above, polycondensation products of an alcohol, such as dipropylene glycol, 1,4-butanediol, 1,6-hexanediol, or neopentyl glycol with a dibasic acid, such as adipic acid, azelaic acid, or sebacic acid; lactone-based ring-opening polymer polyols, such as polycaprolactone; and polycarbonate diol. For example, carboxy-containing polyols such as 2,2-dimethylolpropionic acid, and 2,2-dimethylolbutanoic acid are also usable.

[0079]

Examples of the polyisocyanate for reacting with a polyol include aliphatic polyisocyanates, such as hexamethylene diisocyanate, trimethyl hexamethylene diisocyanate, dimeric acid diisocyanate, and lysine diisocyanate; biuret-type adducts of these polyisocyanates, and isocyanurate-ring adducts of these polyisocyanates; alicyclic diisocyanates, such as isophorone diisocyanate, 4,4′-methylene bis(cyclohexylisocyanate), methyl cyclohexane-2,4-(or -2,6-)diisocyanate, 1,3-(or 1,4-) di(isocyanatomethyl) cyclohexane, 1,4-cyclohexane diisocyanate, 1,3-cyclopentane diisocyanate, and 1,2-cyclohexane diisocyanate; biuret-type adducts of these polyisocyanates, and isocyanurate-ring adducts of these polyisocyanates; aromatic diisocyanate compounds, such as xylylene diisocyanate, meta-xylylene diisocyanate, tetramethyl xylylene diisocyanate, tolylene diisocyanate, 4,4'-diphenyl methane diisocyanate, 1,5-naphthalene diisocyanate, 1,4-naphthalene diisocyanate, 4,4-toluidine diisocyanate, 4,4'-diphenyl ether diisocyanate, (m- or p-) phenylene diisocyanate, 4,4'-biphenylene diisocyanate, 3,3'-dimethyl-4,4'-biphenylene diisocyanate, bis(4-isocyanatophenyl) sulfone, and isopropylidene bis(4-phenylisocyanate); biuret-type adducts of these polyisocyanates, and isocyanurate-ring adducts of these polyisocyanates; polyisocyanates having three or more isocyanate groups per molecule, such as triphenyl methane-4,4',4''-triisocyanate, 1,3,5-triisocyanatobenzene, 2,4,6-

triisocyanato toluene, and 4,4'-dimethyldiphenylmethane-2,2',5,5'-tetraisocyanate; and biuret-type adducts of these polyisocyanates, and isocyanurate-ring adducts of these polyisocyanates.

[0080]

The hydroxy value of the hydroxy-containing polyurethane resin is preferably within the range of 80 to 250 mg KOH/g, and more preferably 100 to 200 mg KOH/g. The weight average molecular weight of the hydroxy-containing polyurethane resin is preferably within the range of 500 to 10000, and more preferably 1000 to 5000.

[0081]

When the hydroxy-containing acrylic resin (A1-1) and a resin other than the hydroxy-containing acrylic resin (A1-1) (more specifically, polyester resin, polyurethane resin, polyether resin etc.) are used in combination as the binder component (A), the content of the resin other than the hydroxy-containing acrylic resin (A1-1) is preferably within the range of 50 parts by mass or less, and more preferably 1 to 20 parts by mass, per 100 parts by mass of the solids content of the hydroxy-containing acrylic resin (A1-1).

[0082]

Crosslinking agent (A2)

In the paint composition of the present invention, the binder component (A) can contain a crosslinking agent (A2). The crosslinking agent (A2) is a compound that can react with a crosslinkable functional group in the binder component (A), and that can form a cross-linking structure by the reaction. It is preferable that the crosslinkable functional group in the binder component (A) is a hydroxy group, and that the crosslinking agent (A2) is a compound having reactivity with a hydroxy group.

[0083]

Specifically, for example, the crosslinking agent (A2) is preferably a polyisocyanate compound, a blocked polyisocyanate compound, or an amino resin. In particular, from the viewpoint of the finished appearance, scratch resistance, and the like, the crosslinking agent (A2) preferably contains a polyisocyanate compound.

[0084]

The polyisocyanate compound is a compound having at least two isocyanate groups per molecule. Examples include aliphatic polyisocyanate compounds, alicyclic polyisocyanate compounds, aromatic-aliphatic polyisocyanate compounds, aromatic polyisocyanate compounds, derivatives of these polyisocyanate compounds, and the like.

[0085]

Examples of aliphatic polyisocyanate compounds include aliphatic diisocyanate compounds, such as trimethylene diisocyanate, tetramethylene diisocyanate, hexamethylene diisocyanate, pentamethylene diisocyanate, 1,2-propylene diisocyanate, 1,2-butylene diisocyanate, 2,3-butylene diisocyanate, 1,3-butylene diisocyanate, 2,4,4- or 2,2,4-trimethylhexamethylene diisocyanate, dimer acid diisocyanate, and methyl 2,6-diisocyanatohexanoate (common name: lysine diisocyanate); aliphatic triisocyanate compounds, such as 2-isocyanatoethyl 2,6-diisocyanatohexanoate, 1,6-diisocyanato-3-isocyanatomethylhexane, 1,4,8-triisocyanatooctane, 1,6,11-triisocyanatoundecane, 1,8-diisocyanato-4-isocyanatomethyloctane, 1,3,6-triisocyanatohexane, and 2,5,7-trimethyl-1,8-diisocyanato-5-isocyanatomethyloctane; and the like.

[0086]

Examples of alicyclic polyisocyanate compounds include alicyclic diisocyanate compounds, such as 1,3-cyclopentene diisocyanate, 1,4-cyclohexane diisocyanate, 1,3-cyclohexane diisocyanate, 3-isocyanatomethyl-3,5,5-trimethylcyclohexyl isocyanate (common name: isophorone diisocyanate), 4-methyl-1,3-cyclohexylene diisocyanate (common name: hydrogenated TDI), 2-methyl-1,3-cyclohexylene diisocyanate, 1,3- or 1,4-bis(isocyanatomethyl)cyclohexane (common name: hydrogenated xylylene diisocyanate) or mixtures thereof, and methylenebis(4,1-

cyclohexanediyl)diisocyanate (common name: hydrogenated MDI), and norbornane diisocyanate; alicyclic triisocyanate compounds, such as 1,3,5-triisocyanatocyclohexane, 1,3,5-trimethylisocyanatocyclohexane, 2-(3-isocyanatopropyl)-2,5-di(isocyanatomethyl)-bicyclo(2.2.1)heptane, 2-(3-isocyanatopropyl)-2,6-di(isocyanatomethyl)-bicyclo(2.2.1)heptane, 3-(3-isocyanatopropyl)-2,5-di(isocyanatomethyl)-bicyclo(2.2.1)heptane, 5-(2-isocyanatoethyl)-2-isocyanatomethy-3-(3-isocyanatopropyl)-bicyclo(2.2.1)heptane, 6-(2-isocyanatoethyl)-2-isocyanatomethyl-3-(3-isocyanatopropyl)-bicyclo(2.2.1)heptane, 5-(2-isocyanatoethyl)-2-isocyanatomethyl-2-(3-isocyanatopropyl)-bicyclo(2.2.1)heptane, and 6-(2-isocyanatoethyl)-2-isocyanatomethyl-2-(3-isocyanatopropyl)-bicyclo(2.2.1)heptane; and the like.

[0087]

Examples of aromatic-aliphatic polyisocyanate compounds include aromatic-aliphatic diisocyanate compounds, such as methylenebis(4,1-phenylene)diisocyanate (common name: MDI), 1,3- or 1,4-xylylene diisocyanate or mixtures thereof, ω,ω′-diisocyanato-1,4-diethylbenzene, and 1,3- or 1,4-bis(1-isocyanato-1-methylethyl)benzene (common name: tetramethylxylylene diisocyanate) or mixtures thereof; aromatic-aliphatic triisocyanate compounds, such as 1,3,5-triisocyanatomethylbenzene; and the like.

[0088]

Examples of aromatic polyisocyanate compounds include aromatic diisocyanate compounds, such as m-phenylene diisocyanate, p-phenylene diisocyanate, 4,4′-diphenyldiisocyanate, 1,5-naphthalene diisocyanate, 2,4-tolylene diisocyanate (common name: 2,4-TDI) or 2,6-tolylene diisocyanate (common name: 2,6-TDI) or mixtures thereof, 4,4′-toluidine diisocyanate, and 4,4′-diphenylether diisocyanate; aromatic triisocyanate compounds, such as triphenylmethane-4,4′,4′′-triisocyanate, 1,3,5-triisocyanatobenzene, and 2,4,6-triisocyanatotoluene; aromatic tetraisocyanate compounds, such as

4,4′-diphenylmethane-2,2′,5,5′- tetraisocyanate; and the like.

[0089]

Examples of derivatives of the polyisocyanate compounds include dimers, trimers, biurets, allophanates, uretdiones, uretimine, isocyanurates, oxadiazinetriones, polymethylene polyphenyl polyisocyanates (crude MDI, polymeric MDI), crude TDI, and the like, of the polyisocyanate compounds mentioned above.

[0090]

The polyisocyanate compounds and derivatives thereof mentioned above may be used singly, or in a combination of two or more.

[0091]

From the viewpoint of the weatherability etc. of the resulting coating film, the polyisocyanate compound for use is preferably at least one member selected from the group consisting of an aliphatic polyisocyanate compound, an alicyclic polyisocyanate compound, and a derivative thereof. From the viewpoint of an increase in the solids content of the obtained paint composition, and the finished appearance and scratch resistance of the resulting coating film, the polyisocyanate compound for use is more preferably an aliphatic polyisocyanate compound and/or a derivative thereof.

[0092]

The aliphatic polyisocyanate compound and/or a derivative thereof for use is preferably an aliphatic diisocyanate compound and/or an isocyanurate thereof, and more preferably hexamethylene diisocyanate and/or an isocyanurate thereof, from the viewpoint of an increase in the solids content of the obtained paint composition, and the finished appearance and scratch resistance of the resulting coating film.

[0093]

When the paint composition of the present invention contains a polyisocyanate compound described above as the crosslinking agent (A2), the proportion of the polyisocyanate compound is preferably within the range of 5 to 60 parts by mass, more preferably 15 to 50 parts by mass, and still more preferably 25 to 45 parts by mass, per 100 parts by mass of the total solids content of the hydroxy-containing resin (A1) and the crosslinking agent (A2), from the viewpoint of the finished appearance and scratch resistance of the resulting coating film.

[0094]

The blocked polyisocyanate compound usable as the crosslinking agent (A2) is a compound obtained by blocking isocyanate groups of a polyisocyanate compound described above with a blocking agent.

[0095]

Examples of blocking agents include phenol compounds, such as phenol, cresol, xylenol, nitrophenol, ethylphenol, hydroxydiphenyl, butylphenol, isopropylphenol, nonylphenol, octylphenol, and methyl hydroxybenzoate; lactam compounds, such as ε-caprolactam, δ-valerolactam, γ-butyrolactam, and β-propiolactam; aliphatic alcohol compounds, such as methanol, ethanol, propyl alcohol, butyl alcohol, amyl alcohol, and lauryl alcohol; ether compounds, such as ethylene glycol monomethyl ether, ethylene glycol monoethyl ether, ethylene glycol monobutyl ether, diethylene glycol monomethyl ether, diethylene glycol monoethyl ether, propylene glycol monomethyl ether, and methoxymethanol; alcohol compounds, such as benzyl alcohol, glycolic acid, methyl glycolate, ethyl glycolate, butyl glycolate, lactic acid, methyl lactate, ethyl lactate, butyl lactate, methylol urea, methylol melamine, diacetone alcohol, 2-hydroxyethyl acrylate, and 2-hydroxyethyl methacrylate; oxime compounds, such as formamide oxime, acetamide oxime, acetoxime, methyl ethyl ketoxime, diacetyl monoxime, benzophenone oxime, and cyclohexane oxime; active methylene compounds, such as dimethyl malonate, diethyl malonate, ethyl acetoacetate, methyl acetoacetate, and acetylacetone; mercaptan compounds, such as butyl mercaptan, t-butyl mercaptan, hexyl mercaptan, t-dodecyl mercaptan, 2-mercaptobenzothiazole, thiophenol, methylthiophenol, and ethylthiophenol; acid amide compounds, such as acetanilide, acetanisidide, acetotoluide, acrylamide, methacrylamide, acetic acid amide, stearic acid amide, and benzamide; imide compounds, such as succinimide, phthalimide, and maleimide; amine compounds, such as diphenylamine, phenylnaphthylamine, xylidine, N-phenylxylidine, carbazole, aniline, naphthylamine, butylamine, dibutylamine, and butylphenylamine; imidazole compounds, such as imidazole and 2-ethylimidazole; urea compounds, such as urea, thiourea, ethylene urea, ethylenethiourea, and diphenylurea; carbamate compounds, such as phenyl N-phenylcarbamate; imine compounds, such as ethyleneimine and propyleneimine; sulfite compounds, such as sodium bisulfite and potassium bisulfite; azole compounds; and the like. Examples of the azole compounds include pyrazole or pyrazole derivatives, such as pyrazole, 3,5-dimethylpyrazole, 3-methylpyrazole, 4-benzyl-3,5-dimethylpyrazole, 4-nitro-3,5-dimethylpyrazole, 4-bromo-3,5-dimethylpyrazole, and 3-methyl-5-phenylpyrazole; imidazole or imidazole derivatives, such as imidazole, benzimidazole, 2-methylimidazole, 2-ethylimidazole, and 2-phenylimidazole; imidazoline derivatives, such as 2-methylimidazoline and 2-phenylimidazoline; and the like.

[0096]

Particularly preferable blocking agents are, for example, oxime-based blocking agents, active methylene-based blocking agents, and pyrazole or pyrazole derivatives.

[0097]

When blocking is performed (a blocking agent is reacted), a solvent may be added, if necessary. The solvent used in the blocking reaction is preferably a solvent that is not reactive with an isocyanate group. Examples of such solvents include ketones, such as acetone and methyl ethyl ketone; esters, such as ethyl acetate; N-methyl-2-pyrrolidone (NMP); and the like.

[0098]

When the paint composition of the present invention contains a blocked polyisocyanate compound described above as the crosslinking agent (A2), the proportion of the blocked polyisocyanate compound is preferably within the range of 5 to 60 parts by mass, more preferably 15 to 50 parts by mass, and still more preferably 25 to 45 parts by mass, per 100 parts by mass of the total solids content of the binder component, from the viewpoint of the finished appearance and scratch resistance of the resulting coating film.

[0099]

When the paint composition of the present invention contains a polyisocyanate compound and/or a blocked polyisocyanate compound described above as the crosslinking agent (A2), the proportion is preferably such that the equivalent ratio (NCO/OH) of the total of the isocyanate groups (including blocked isocyanate groups) in the polyisocyanate compound and the blocked polyisocyanate compound to the hydroxy groups of the hydroxy-containing resin (A1) is generally within the range of 0.5 to 2, and preferably 0.8 to 1.5, from the viewpoint of the water resistance and finished appearance of the resulting coating film.

[0100]

Amino resins usable as the crosslinking agent (A2) include partially or fully methylolated amino resins obtained by a reaction of an amino component with an aldehyde component. Examples of amino components include melamine, urea, benzoguanamine, acetoguanamine, steroguanamine, spiroguanamine, dicyandiamide, and the like. Examples of aldehyde components include formaldehyde, paraformaldehyde, acetaldehyde, benzaldehyde, and the like.

[0101]

Also usable are those obtained by etherifying some or all of the methylol groups of the above methylolated amino resins with a suitable alcohol. Examples of alcohols usable for etherification include methyl alcohol, ethyl alcohol, n-propyl alcohol, isopropyl alcohol, n-butyl alcohol, isobutyl alcohol, 2-ethylbutanol, 2-ethylhexanol, and the like.

[0102]

Preferred amino resins are melamine resins. Examples of usable melamine resins include alkyl-etherified melamine resins obtained by etherifying some or all of the methylol groups of partially or fully methylolated melamine resins with the alcohol.

[0103]

Preferable examples of alkyl-etherified melamine resins include methyl-etherified melamine resins obtained by etherifying some or all of the methylol groups of partially or fully methylolated melamine resins with methyl alcohol; butyl-etherified melamine resins obtained by etherifying some or all of the methylol groups of partially or fully methylolated melamine resins with butyl alcohol; methyl-butyl mixed etherified melamine resins obtained by etherifying some or all of the methylol groups of partially or fully methylolated melamine resins with methyl alcohol and butyl alcohol; and the like.

[0104]

The melamine resin has a weight average molecular weight of preferably 400 to 6000, more preferably 500 to 5000, and still more preferably 800 to 4000.

[0105]

A commercially available product can be used as the melamine resin. Examples of the commercially available product include Cymel 202, Cymel 203, Cymel 238, Cymel 251, Cymel 303, Cymel 323, Cymel 324, Cymel 325, Cymel 327, Cymel 350, Cymel 385, Cymel 1156, Cymel 1158, Cymel 1116, Cymel 1130, (all produced by Allnex Japan Inc.), U-VAN 120, U-VAN 20HS, U-VAN 20SE60, U-VAN 2021, U-VAN 2028, U-VAN 28-60 (all produced by Mitsui Chemicals, Inc.), and the like.

[0106]

The melamine resins described above may be used singly, or in a combination of two or more.

[0107]

When the paint composition of the present invention contains an amino resin described above as the crosslinking agent (A2), its proportion is preferably within the range of 0.5 to 40 parts by mass, more preferably 1.0 to 15 parts by mass, still more preferably 1.5 to 10 parts by mass, and even more preferably 1.5 to 5 parts by mass, per 100 parts by mass of the total solids content of the binder component, from the viewpoint of the water resistance and finished appearance of the resulting coating film.

[0108]

The crosslinking agents (A2) may be used singly, or in a combination of two or more.

[0109]

Rheology control agent

In general, it is preferable for a paint composition to have a low viscosity when the shear rate is high, such as during atomization, and a high viscosity when the shear rate is low, such as during coating (e.g., by a coating method such as air spray coating, airless spray coating, rotary atomization coating, etc.); this is because such a paint composition can form a coating film with an excellent appearance. Specifically, a paint with a viscosity that decreases along with an increase in shear rate is preferable. A rheology control agent is a component added to a paint composition in order to develop a desired viscosity.

[0110]

First rheology control agent (B)

The first rheology control agent (B) contains a reaction product of (b1) a polyisocyanate compound, (b2) a primary monoamine having a number average molecular weight of 300 or less, and (b3) a polyether amine having a number average molecular weight of more than 300 and less than 6000, wherein the proportion of the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) is 0.5 mass% or more and less than 10 mass% based on the total amount of the components (b1) to (b3).

[0111]

Polyisocyanate compound (b1)

The polyisocyanate compound (b1) for use may be, for example, a polyisocyanate compound mentioned above in the description of the crosslinking agent (A2). The polyisocyanate compounds may be used singly, or in a combination of two or more.

[0112]

The polyisocyanate compound (b1) is preferably an aliphatic polyisocyanate compound and/or a derivative thereof, more preferably an aliphatic diisocyanate compound and/or an isocyanurate thereof, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film. Among these, hexamethylene diisocyanate and/or an isocyanurate thereof is preferable, and hexamethylene diisocyanate is more preferable.

[0113]

Primary monoamine having a number average molecular weight of 300 or less (b2)

Examples of the primary monoamine having a number average molecular weight of 300 or less (b2) include benzylamine, ethylamine, n-propylamine, sec-propylamine, n-butylamine, sec-butylamine, tert-butylamine, n-pentylamine, α-methylbutylamine, α-ethylpropylamine, β-ethylbutylamine, hexylamine, octylamine, 2-ethylhexylamine, n-decylamine, 1-aminooctadecane (stearylamine), cyclohexylamine, aniline, 2-(2-aminoethoxy)ethanol, and the like. The primary monoamines (b2) may be used singly, or in a combination of two or more.

[0114]

As the primary monoamine having a number average molecular weight of 300 or less (b2), a benzene ring-containing primary monoamine is preferable, and benzylamine is more preferable, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film.

[0115]

The number average molecular weight of the primary monoamine having a number average molecular weight of 300 or less (b2) is preferably within the range of 60 to 300, more preferably

75 to 250, and still more preferably 90 to 150, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film.

[0116]

Polyether amine (b3)

The polyether amine (b3) is an amine having a number average molecular weight of more than 300 and less than 6000, and containing two or more ether linkages per molecule.

[0117]

In particular, the number average molecular weight of the polyether amine (b3) is within the range of preferably 300 to 4000, more preferably 320 to 3000, and still more preferably 350 to 2000, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film.

[0118]

From the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film, the polyether amine (b3) is preferably a primary amine.

[0119]

The polyether amine (b3) is preferably at least one amine selected from the group consisting of monoamine, diamine, and triamine, from the viewpoint of the transparency of the resulting coating film. In particular, the polyether amine (b3) is more preferably a diamine, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film.

[0120]

Therefore, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film, the polyether amine (b3) is preferably at least one amine selected from the group consisting of primary monoamine, primary diamine, and primary triamine, and more preferably primary diamine. In the present invention, the primary diamine is an amine having two $-NH_2$ groups, and the primary triamine is an amine having three -NH_2 groups.

[0121]

As the polyether amine (b3), for example, a polyoxyalkylene-containing amine can be preferably used.

[0122]

From the viewpoint of the transparency of the resulting coating film, at least one amine compound selected from the group consisting of polyoxyalkylene-containing monoamine represented by formula (1) below (b3-1), polyoxyalkylene-containing diamine represented by formula (3) below (b3-2), and polyoxyalkylene-containing polyamine having three or more amino groups represented by formula (6) below (b3-3) can be preferably used as the polyoxyalkylene-containing amine.

[0123]

Of these, the polyoxyalkylene-containing diamine (b3-2) can be particularly preferably used from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film.

[0124]

Polyoxyalkylene-containing monoamine (b3-1)

The polyoxyalkylene-containing monoamine (b3-1) is a polyoxyalkylene-containing monoamine represented by formula (1) below.

[0125]

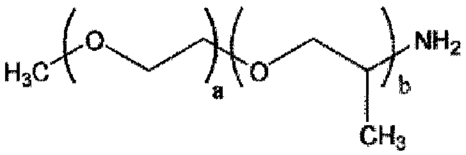
$$R^1 - \left[O - R^2 \right]_m - NH_2 \qquad (1)$$

[0126]

(wherein R^1 represents a monovalent organic group, preferably a monovalent hydrocarbon group, more preferably a C_{1-4} alkyl group; R^2 represents a C_{2-6} alkylene group, preferably a C_{2-4} alkylene group, more preferably at least one alkylene group selected from the group consisting of an ethylene group, a propylene group, and a tetramethylene group; m represents an integer of 2 to 70, preferably 4 to 60, more preferably 5 to 50; m oxyalkylene units ($O-R^2$) may be the same or different; and when the oxyalkylene units (O-R^2) are different from each other, the form of addition (polymerization form) of the oxyalkylene units (O-R^2) may be a random form, or a block form.)

Specifically, as the polyoxyalkylene-containing monoamine (b3-1), a polyoxyalkylene-containing monoamine represented by formula (2) below can be preferably used.

[0127]



(2)

[0128]

(wherein a represents an integer of 1 to 35, preferably 1 to 30, more preferably 1 to 25; and b represents an integer of 1 to 35, preferably 2 to 30, and more preferably 3 to 25.)

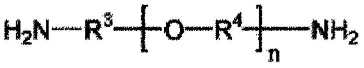
A commercially available product can be used as the polyoxyalkylene-containing monoamine (b3-1). Examples of the commercially available product include JEFFAMINE M-600 (number average molecular weight: 600; in formula (2) above, a = 1, and b = 9), JEFFAMINE™ M-1000 (number average molecular weight: 1000; in formula (2) above, a = 19, and b = 3), JEFFAMINE M-2005 (number average molecular weight: 2000; in formula (2) above, a = 6, and b = 29), JEFFAMINE M-2070 (number average molecular weight: 2000; in formula (2) above, a = 31, and b = 10) (all produced by Huntsman Corporation), and the like.

[0129]

Polyoxyalkylene-containing diamine (b3-2)

The polyoxyalkylene-containing diamine (b3-2) is a polyoxyalkylene-containing diamine represented by formula (3) below.

[0130]



$$H_2N-R^3-\left[O-R^4\right]_n-NH_2 \qquad (3)$$

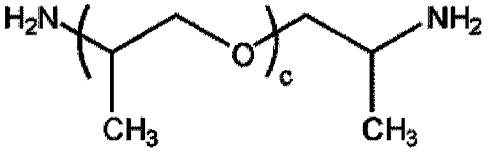
[0131]

(wherein R^3 represents a C_{2-6} alkylene group, preferably a C_{2-4}

alkylene group, more preferably at least one alkylene group selected from the group consisting of an ethylene group, a propylene group, and a tetramethylene group; R^4 represents a C_{2-6} alkylene group, preferably a C_{2-4} alkylene group, more preferably at least one alkylene group selected from the group consisting of an ethylene group, a propylene group, and a tetramethylene group; n represents an integer of 2 to 70, preferably 4 to 60, more preferably 5 to 50; n oxyalkylene units ($O-R^4$) may be the same or different; and when the oxyalkylene units ($O-R^4$) are different from each other, the form of addition (polymerization form) of the oxyalkylene units ($O-R^4$) may be a random form, or a block form.)

Specifically, the polyoxyalkylene-containing diamine (b3-2) for use is preferably a polyoxyalkylene-containing diamine represented by formula (4) below

[0132]



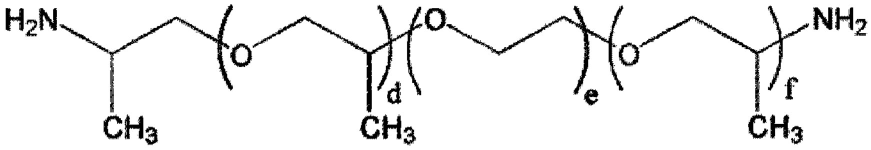
(4)

[0133]

(wherein c represents an integer of 2 to 70, preferably 3 to 60, and more preferably 4 to 50)

and/or a polyoxyalkylene-containing diamine represented by formula (5) below

[0134]



(5)

[0135]

(wherein d and f each represent an integer of 0 to 40, preferably 1 to 20, more preferably 1 to 10; e represents an integer of 2 to 40, preferably 4 to 35, more preferably 6 to 30; and d+f is within the range of 1 to 80, in particular, preferably 1 to 10, more preferably 2 to 9, and even more preferably 3 to 8).

[0136]

A commercially available product can be used as the polyoxyalkylene-containing diamine (b3-2). Examples of the commercially available product include JEFFAMINE D-400 (number average molecular weight: 430; in formula (4) above, c ≈ 6.1 (average value)), JEFFAMINE D-2000 (number average molecular weight: 2000; in formula (4) above, c ≈ 33), JEFFAMINE D-4000 (number average molecular weight: 4000; in formula (4) above, c ≈ 68), JEFFAMINE ED-600 (number average molecular weight: 600; in formula (5) above, d+f ≈ 3.6 (average value), e ≈ 9), JEFFAMINE ED-900 (number average molecular weight: 900; in formula (5) above, d+f ≈ 6, e ≈ 12.5 (average value)), JEFFAMINE ED-2003 (number average molecular weight: 2000; in formula (5) above, d+f ≈ 6, e ≈ 39), ELASTAMINE RT-1000 (number average molecular weight: 1000) (all produced by Huntsman Corporation), and the like.

[0137]

Polyoxyalkylene-containing polyamine (b3-3)

The polyoxyalkylene-containing polyamine (b3-3) is a polyoxyalkylene-containing polyamine having three or more amino groups represented by formula (6) below

[0138]

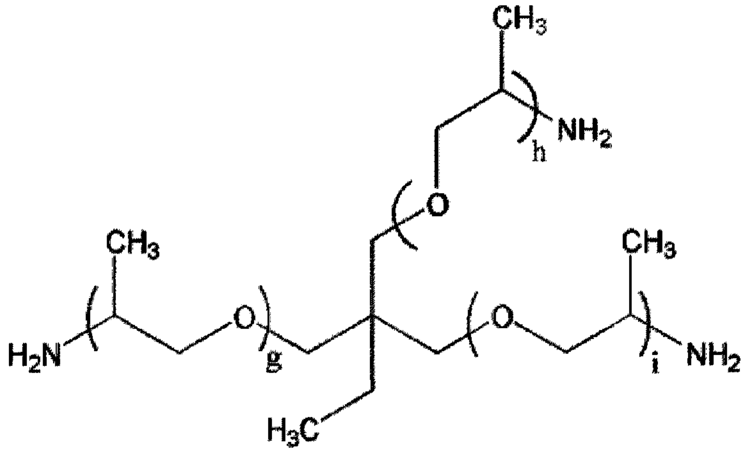
$$R^5 \left[\left[O-R^6 \right]_p NH_2 \right]_q \qquad (6)$$

[0139]

(wherein R^5 represents a q-valent organic group having a carbon atom at a bonding site with the oxygen atom indicated in the formula, preferably a q-valent hydrocarbon group; R^6 represents a C_{2-6} alkylene group, preferably a C_{2-4} alkylene group, more preferably at least one alkylene group selected from the group consisting of an ethylene group, a propylene group, and a tetramethylene group; p represents an integer of 2 to 70, preferably 4 to 60, more preferably 5 to 50; q represents an integer of 3 or more, preferably 3 to 6, more preferably 3 or 4; p oxyalkylene units (O-R^6) may be the same or different; and when the oxyalkylene units (O-R^6) are different from each other, the form of addition (polymerization form) of the oxyalkylene units (O-R^6) may be a random form or a block form).

Specifically, the polyoxyalkylene-containing polyamine (b3-3) for use is preferably a polyoxyalkylene-containing triamine represented by formula (7) below

[0140]



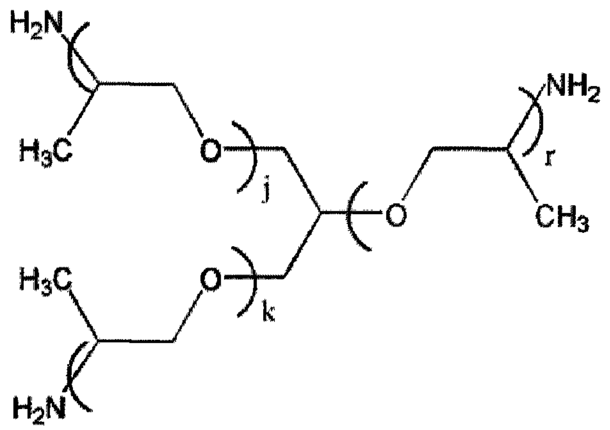
(7)

[0141]

(wherein g, h, and i each represent an integer of 1 to 40, preferably 1 to 30, more preferably 1 to 20; in particular, it is preferred that g+h+i is within the range of 3 to 40, preferably 4 to 30, more preferably 5 to 20)

and/or a polyoxyalkylene-containing triamine represented by formula (8) below

[0142]



(8)

[0143]

(wherein j, k, and r each represent an integer of 1 to 90, preferably 1 to 75, more preferably 1 to 60; in particular, it is preferred that j+k+r is within the range of 3 to 90, preferably 4 to 75, more preferably 5 to 60).

[0144]

A commercially available product can be used as the polyoxyalkylene-containing polyamine (b3-3). Examples of the commercially available product include JEFFAMINE T-403 (number average molecular weight: 440; in formula (7) above, g+h+i = 5 to 6), JEFFAMINE T-3000 (number average molecular weight: 3000; in formula (8) above, j+k+r ≈ 50), JEFFAMINE T-5000 (number average molecular weight: 5000; in formula (8) above, j+k+r ≈ 85) (all produced by Huntsman Corporation), and the like.

[0145]

Reaction method

The reaction of the polyisocyanate compound (b1), the primary monoamine having a number average molecular weight of 300 or less (b2), and the polyether amine having a number average molecular weight of more than 300 but less than 6000 (b3) can be generally performed by mixing the components (b1) to (b3) according to any selected method at, if necessary, elevated temperature. The reaction is performed at a temperature of preferably 5 to 80°C, and more preferably 10 to 60°C.

[0146]

Through this reaction, carbonyls of the polyisocyanate compound (b1) and amines of the primary monoamine having a number average molecular weight of 300 or less (b2) and the polyether amine having a number average molecular weight of more than 300 but less than 6000 (b3) form urea linkages, thus forming a cross-linked structure.

[0147]

Typically, the components (b1) to (b3) can be mixed by any selected method. For example, the components (b1) to (b3) can be mixed by concurrently adding a mixture of the primary monoamine (b2) and the polyether amine (b3) and the polyisocyanate compound (b1) dropwise to a reaction vessel, or by adding the polyisocyanate compound (b1) dropwise to a mixture of the primary monoamine (b2) and the polyether amine (b3). If necessary, the components may be mixed in several stages. The reaction of the components (b1) to (b3) is preferably performed in the presence of an organic solvent.

[0148]

Examples of organic solvents include toluene, xylene, Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an oil-based high-boiling-point solvent), and like aromatic solvents; mineral spirit and like aliphatic solvents; ethyl acetate, butyl acetate, propyl propionate, butyl propionate, 1-methoxy-2-propyl acetate, 2-ethoxyethyl propionate, 3-methoxybutyl acetate, ethylene glycol ethyl ether acetate, propylene glycol methyl ether acetate, and like ester-based solvents; methyl ethyl ketone, methyl isobutyl ketone, methyl amyl ketone, and like ketone-based solvents; isopropanol, n-butanol, iso-butanol, 2-ethylhexanol, and like alcohol-based solvents; and the like.

[0149]

Upon the reaction of the components (b1) to (b3), the proportions of the components (b1) to (b3) are preferably within the following ranges based on the total amount of the components (b1) to (b3), from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film:

Polyisocyanate compound (b1): 30 to 60 mass%, preferably 35 to 55 mass%, and more preferably 40 to 50 mass%;

Primary monoamine having a number average molecular weight of 300 or less (b2): 35 to 65 mass%, preferably 40 to 62 mass%, and more preferably 45 to 60 mass%; and

Polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3): 0.5 to 15 mass%, preferably 1 to 10 mass%, and more preferably 1.5 to 8 mass%.

[0150]

Upon the reaction of the components (b1) to (b3), the ratio of the total number of amino groups in the primary monoamine (b2) and the polyether amine (b3) to the number of isocyanate groups in the polyisocyanate compound (b1) (amino groups/isocyanate groups) is preferably within the range of 0.7 to 1.5, more preferably 0.9 to 1.1, and still more preferably 0.95 to 1.05, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film.

[0151]

In the present invention, the rheology control agent (B) may generally contain a reaction product of the polyisocyanate compound (b1) and the primary monoamine (b2) and may further contain a reaction product of the polyisocyanate compound (b1) and the polyether amine (b3), in addition to the reaction product of the polyisocyanate compound (b1), the primary monoamine (b2), and the polyether amine (b3).

[0152]

Moreover, the reaction of the components (b1) to (b3) is preferably performed in the presence of a resin component, from the viewpoint of suppressing the aggregation of the reaction product.

[0153]

Examples of resin components used in the reaction of the components (b1) to (b3) include acrylic resins, polyester resins, polyether resins, polycarbonate resins, polyurethane resins, epoxy resins, alkyd resins, and the like. Of these, acrylic resins are preferable, from the viewpoint of the transparency, water resistance, and finished appearance of the resulting coating film. The resin component may be the binder component (A) or a resin component that is different from the binder component (A). The resin component for use is preferably a film-forming resin other than the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b), and the secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c). For example, the resin component may be the secondary hydroxy-containing acrylic resin (A1-1a).

[0154]

When the reaction of the components (b1) to (b3) is performed in the presence of the resin component mentioned above, the mixing ratio of the components (b1) to (b3) and the resin component is preferably such that the ratio of the total mass of the components (b1) to (b3) to the mass of the resin component, i.e., the ratio of (the total mass of the components (b1) to (b3))/(the mass of the resin component), is preferably within the range of 3/97 to 15/85, and more preferably 5/95 to 12/88.

[0155]

In the present invention, when the reaction of the components (b1) to (b3) is performed in the presence of the resin component, the resin component is not included in the first rheology control agent (B).

[0156]

Second rheology control agent (C)

The second rheology control agent (C) contains a reaction product of (C1) a polyisocyanate compound, (c2) a primary monoamine having a number average molecular weight of 300 or less, and (c3) a polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000, wherein the proportion of the polyether amine having a number average molecular weight of 1000 or more and less than 6000 (c3) is within the range of 10 to 30 mass%

based on the total amount of the components (c1) to (c3).

[0157]

Polyisocyanate compound (c1)

The polyisocyanate compound (c1) for use may also be a polyisocyanate compound mentioned above in the description of the crosslinking agent (A2), as stated for the polyisocyanate compound (b1) of the first rheology control agent (b). The polyisocyanate compounds may be used singly, or in a combination of two or more.

[0158]

The polyisocyanate compound (c1) is preferably an aliphatic polyisocyanate compound and/or a derivative thereof, more preferably an aliphatic diisocyanate compound and/or an isocyanurate thereof, from the viewpoint of the sag resistance during coating and the water blushing resistance and finished appearance of the resulting coating film. Among these, hexamethylene diisocyanate and/or an isocyanurate thereof is preferable, and hexamethylene diisocyanate is more preferable.

[0159]

Primary monoamine having a number average molecular weight of less than 300 (c2)

The primary monoamine having a number average molecular weight of 300 or less (c2) for use may be the primary monoamine (b2) mentioned in the description of the primary monoamine (b2) of the first rheology control agent (B). The primary monoamine (c2) can be used singly, or in a combination of two or more.

[0160]

As the primary monoamine having a number average molecular weight of 300 or less (c2), a benzene ring-containing primary monoamine is preferable, and benzylamine is more preferable, from the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film.

[0161]

The number average molecular weight of the primary monoamine having a number average molecular weight of 300 or less (c2) is within the range of preferably 60 to 300, more preferably 75 to 250, and still more preferably 90 to 150, from the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film.

[0162]

Polyether amine (c3)

The polyether amine (c3) is a polyether having two or more ether linkages per molecule, and is an amine having two or more amino groups and a number average molecular weight of 1000 or more and less than 6000.

[0163]

In particular, the number average molecular weight of the polyether amine (c3) is within the range of preferably 1000 to 5000, more preferably 2000 to 5000, and still more preferably 2000 to 4000, from the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film.

[0164]

From the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film, the polyether amine (c3) is preferably a primary amine.

[0165]

The polyether amine (c3) has two or more amino groups. From the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film, the polyether amine (c3) is more preferably at least one amine the group consisting of a diamine and a triamine, and particularly preferably a triamine.

[0166]

Therefore, from the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film, the polyether amine (c3) is preferably at least one amine selected from the group consisting of a primary diamine and a primary triamine, and more preferably a primary triamine. In the present invention, the primary diamine is an amine having two $-NH_2$ groups, and the primary triamine is an amine having three $-NH_2$ groups.

[0167]

As the polyether amine (c3), for example, a polyoxyalkylene-containing amine can be preferably used.

[0168]

From the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film, at least one amine compound selected from the group consisting of a polyoxyalkylene-containing diamine represented by formula (9) below (c3-1) and a polyoxyalkylene-containing polyamine having three or more amino groups represented by formula (12) below (c3-2) can be preferably used as the polyoxyalkylene-containing amine.

[0169]

Of these, the polyoxyalkylene-containing polyamine having three or more amino groups (c3-2) can be particularly preferably used from the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film.

[0170]

Polyoxyalkylene-containing diamine (c3-1)

The polyoxyalkylene-containing diamine (c3-1) is a polyoxyalkylene-containing diamine represented by formula (9) below.

[0171]

$$H_2N-R^3-\left[O-R^4\right]_n-NH_2 \qquad (9)$$

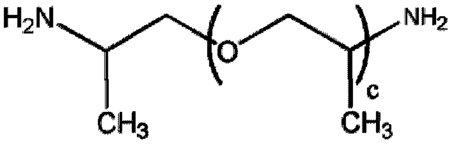
[0172]

(wherein R^3 represents a C_{2-6} alkylene group, preferably a C_{2-4} alkylene group, more preferably at least one alkylene group selected from the group consisting of an ethylene group, a propylene group, and a tetramethylene group; R^4 represents a C_{2-6} alkylene group, preferably a C_{2-4} alkylene group, more preferably at least one alkylene group selected from the group consisting of an ethylene group, a propylene group, and a tetramethylene group; n represents an integer of 9 to 134, preferably 27 to 112, more preferably 27 to 89; n oxyalkylene units ($O-R^4$) may be the same or different; when the oxyalkylene units ($O-R^4$) are different from each other, the form of addition (polymerization form) of the oxyalkylene units ($O-R^4$) may be a random form, or a block form.)

[0173]

Specifically, as the polyoxyalkylene-containing diamine (c3-1), a polyoxyalkylene-containing diamine represented by formula (10) below

[0174]



(10)

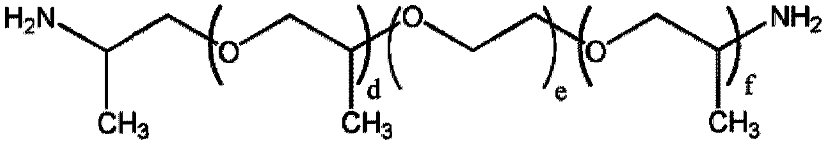
[0175]

(wherein c represents an integer of 16 to 102, preferably 33 to 85, and more preferably 33 to 68)

[0176]

and/or a polyoxyalkylene-containing diamine represented by formula (11) below

[0177]



(11)

[0178]

(wherein d and f each represent an integer of 1 to 20, preferably 2 to 15, more preferably 2 to 10; e represents an integer of 12 to 60, preferably 15 to 50, more preferably 25 to 45; d+f is within the range of 2 to 40, in particular, preferably 4 to 30, more preferably 4 to 20, even more preferably 4 to 8)

[0179]

can be preferably used.

[0180]

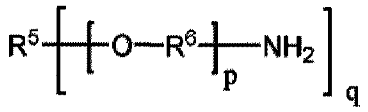
A commercially available product can be used as the polyoxyalkylene-containing diamine (c3-1). Examples of commercially available products include JEFFAMINE D-2000 (number average molecular weight: 2000; in formula (10) above, c ≈ 33), JEFFAMINE D-4000 (number average molecular weight: 4000; in formula (10) above, c ≈ 68), and JEFFAMINE ED-2003 (number average molecular weight: 2000; in formula (11) above, d+f ≈ 6, e ≈ 39), ELASTAMINE RT-1000 (number average molecular weight: 1000).

[0181]

Polyoxyalkylene-containing polyamine (c3-2)

As the polyoxyalkylene-containing polyamine (c3-2), a polyoxyalkylene-containing polyamine having three or more amino groups represented by formula (12) below

[0182]



$$R^5\left[\left(O-R^6\right)_p NH_2\right]_q \qquad (12)$$

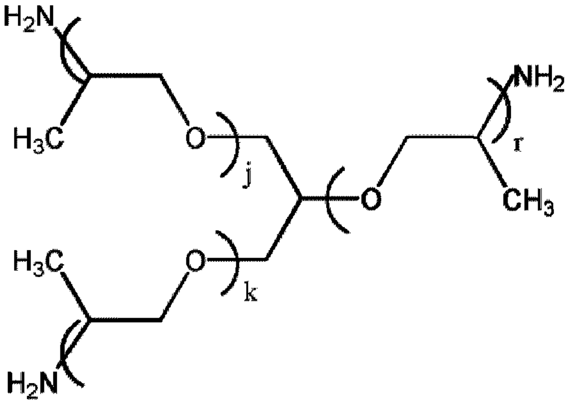
[0183]

(wherein R^5 represents a q-valent organic group having a carbon atom at a bonding site with the oxygen atom indicated in the formula, preferably a q-valent hydrocarbon group; R^6 represents a C_{2-6} alkylene group, preferably a C_{2-4} alkylene group, more preferably at least one alkylene group selected from the group consisting of an ethylene group, a propylene group, and a tetramethylene group; p represents an integer of 4 to 45, preferably 10 to 40, more preferably 15 to 30; q represents an integer of 3 or more, preferably 3 to 6, more preferably 3 or 4; p oxyalkylene units ($O-R^6$) may be the same or different; when the oxyalkylene units ($O-R^6$) are different from each other, the form of addition (polymerization form) of the oxyalkylene units ($O-R^6$) may be a random form, or a block form),

[0184]

and/or polyoxyalkylene-containing triamine represented by formula (13) below

[0185]



(13)

[0186]

(wherein j, k, and r each represent an integer of 5 to 60, preferably 10 to 50, more preferably 10 to 40; in particular, it is preferred that j+k+r is within the range of 17 to 102, preferably 33 to 86, and more preferably 33 to 68)

[0187]

can be preferably used.

[0188]

A commercially available product can be used as the polyoxyalkylene-containing polyamine (c3-3). Examples of commercially available products include JEFFAMINE T-3000 (number average molecular weight: 3000; in formula (13) above, j+k+r ≈ 50), and JEFFAMINE T-5000 (number average molecular weight: 5000; in formula (13) above, j+k+r ≈ 85).

[0189]

Reaction method

The reaction of the polyisocyanate compound (c1), the primary monoamine having a number average molecular weight of 300 or less (c2), and the polyether amine (c3) can be performed by the method described above in section "Reaction method" for (b1) to (b3) in the first rheology control agent (B).

[0190]

Regarding the proportion of the components (c1) to (c3) in reacting the components (c1) to (c3), the proportion of the polyether amine (c3) is within the range of 10 to 30 mass% based on the total amount of the components (c1) to (c3) from the viewpoint of the sag resistance during coating, and the water blushing resistance and finished appearance of the resulting coating film.

[0191]

Upon the reaction of the components (c1) to (c3), the proportions of the components (c1) to (c3) are preferably within the following ranges based on the total amount of the components (c1) to (c3) from the viewpoint of the sag resistance during coating, and the water blushing resistance and the finished appearance of the resulting coating film:

Polyisocyanate compound (c1): 30 to 60 mass%, preferably 30 to 55 mass%, and more preferably 30 to 45 mass%;

Primary monoamine having a number average molecular weight of 300 or less (c2): 30 to 60 mass%, preferably 35 to 60 mass%, and more preferably 35 to 55 mass%; and

Polyether amine (c3): 10 to 30 mass%, preferably more than 15 mass% and 30 mass% or less, and more preferably 18 to 28 mass%.

[0192]

Upon the reaction of the components (c1) to (c3), the ratio of the total number of amino groups in the primary monoamine (c2) and the polyether amine (c3) to the number of isocyanate groups in the polyisocyanate compound (c1) (amino groups/isocyanate groups) is within the range of preferably 0.7 to 1.5, more preferably 0.9 to 1.1, and still more preferably 0.95 to 1.05, from the viewpoint of sag resistance during coating, and water blushing resistance and finished appearance of the resulting coating film.

[0193]

In the present invention, the second rheology control agent (C) may contain a reaction product of the polyisocyanate compound (c1) and the primary monoamine (c2), or a reaction product of the polyisocyanate compound (c1) and the polyether amine (c3), other than the reaction product of the polyisocyanate compound (c1), the primary monoamine (c2), and the polyether amine (c3).

[0194]

Moreover, the reaction of the components (c1) to (c3) is preferably performed in the presence of a resin component, from the viewpoint of suppressing the aggregation of the reaction product.

[0195]

Examples of resin components used in the reaction of the components (c1) to (c3) include acrylic resins, polyester resins, polyether resins, polycarbonate resins, polyurethane resins, epoxy resins, alkyd resins, and the like. Of these, acrylic resins are preferable from the viewpoint of sag resistance during coating, and water blushing resistance and finished appearance of the resulting coating film. The resin component may be a binder component (A), or a resin component that is different from the binder component (A). Preferably, a film-forming resin, such as the secondary hydroxy-containing acrylic resin (A1-1a) described above, other than the hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b) described above, and the secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1c) described above, is used as the resin component.

[0196]

When the reaction of the components (c1) to (c3) is performed in the presence of the resin component, the mixing ratio of the components (c1) to (c3) to the resin component is preferably such that the ratio of the total mass of the components (c1) to (c3) to the mass of the resin component, i.e., the ratio of (the total mass of the components (c1) to (c3))/(mass of the resin component), is preferably within the range of 1/99 to 15/85, and more preferably 2/98 to 12/88.

In the present invention, when the reaction of the components (c1) to (c3) is performed in the presence of the resin component, the resin component is not included in the second rheology control agent (C).

As long as the first rheology control agent (B) and the second rheology control agent (C) are different, the polyisocyanate (b1) of the first rheology control agent (B) and the polyisocyanate compound (c1) of the second rheology control agent (C) may be the same or different, the primary monoamine having a number average molecular weight of 300 or less (b2) of the first rheology control agent (B) and the primary monoamine having a number average molecular weight of 300 or less (c2) of the second rheology control agent (C) may be the same or different, and the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) of the first rheology control agent (B) and the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) of the second rheology control agent (C) may be the same or different.

In one embodiment, the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) of the first rheology control agent (B) differs from the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) of the second rheology control agent (C). The polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) of the first rheology control agent (B) contains a polyether amine having a number average molecular weight of more than 300 and less than 1000; and this polyether amine having a number average molecular weight of more than 300 and less than 1000 contains at least one amine compound selected from the group consisting of polyoxyalkylene-containing monoamine represented by formula (1) (b3-1), polyoxyalkylene-containing diamine represented by formula (3) (b3-2), and polyoxyalkylene-containing polyamine having three or more amino groups represented by formula (6) (b3-3).

In another embodiment, the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) of the first rheology control agent (B) is the same as the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) of the second rheology control agent (C); however, the proportion of the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) based on the total mass of (b1) to (b3) is different from the proportion of the polyether amine having a number average molecular weight of 1000 or more and less than 6000 (c3) based on the total mass of (c1) to (c3).

[0197]

Paint composition

The paint composition of the present invention (hereinafter sometimes simply referred to as "the paint of the present invention") is a paint composition containing the binder component (A), the first rheology control agent (B), and the second rheology control agent (C).

[0198]

From the viewpoint of the sag resistance during coating and the water blushing resistance and finished appearance of the resulting coating film, the content of the first rheology control agent (B) in the paint composition of the present invention is preferably within the range of 0.1 to 2 parts by mass, more preferably 0.1 to 1 parts by mass, and still more preferably 0.2 to 0.6 parts by mass, per 100 parts by mass of the total solids content of the binder component (A).

[0199]

From the viewpoint of the sag resistance during coating and the water blushing resistance and finished appearance of the resulting coating film, the content of the second rheology control agent (C) in the paint composition of the present invention is preferably within the range of 0.1 to 2 parts by mass, more preferably 0.1 to 1 parts by mass, and still more preferably 0.2 to 0.8 parts by mass, per 100 parts by mass of the total solids content of the binder component (A).

[0200]

In the paint composition of the present invention, the ratio of the content of the first rheology control agent (B) and the content of the second rheology control agent (C) is not particularly limited. From the viewpoint of the sag resistance during coating and the water blushing resistance and the finished appearance of the resulting coating film, for example, the mass ratio of the first rheology control agent (B) to the second rheology control agent (C) of (B):(C) is preferably 1:0.5 to 1:2, more preferably 1:1 to 1:2, and still more preferably 1:1 to 1:1.5.

[0201]

The paint composition of the present invention has excellent sag resistance during coating, and is capable of forming a coating film having excellent finished appearance and water blushing resistance. For example, this is because the second rheology control agent (C) is used, and because the first rheology control agent (B) and the second rheology control agent (C) are used in combination.

[0202]

The second rheology control agent (C) is a reaction product of the polyisocyanate compound (c1), the primary monoamine having a number average molecular weight of 300 or less (c2), and the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3). It is assumed that this second rheology control agent (C) contained in the paint composition serves as a rheology control agent with a fine crystalline structure and forms a dense network in the paint composition to exert sag control capability, thus improving the sag resistance during coating and the finished appearance of the resulting coating film. Further, the fine crystalline structure improves the solubility during the coating film formation; therefore, a coating film excellent in water blushing resistance is formed.

[0203]

Furthermore, the first rheology control agent (B) and the second rheology control agent (C) when used in combination are assumed to form two networks with different dissolution temperatures in the paint composition, thus improving the flowability, and further improving the finished appearance while ensuring sag control capability.

[0204]

The paint composition of the present invention may further contain, if necessary, color pigments, effect pigments, dyes, or the like. The paint composition of the present invention may also further contain extender pigments, ultraviolet absorbers, light stabilizers, catalysts, antifoaming agents, rheology control agents other than the first rheology control agent (B) and the second rheology control agent (C), anticorrosives, surface-adjusting agents, organic solvents, and the like.

[0205]

Examples of color pigments include titanium oxide, zinc white, carbon black, cadmium red, molybdenum red, chrome yellow, chromium oxide, Prussian blue, cobalt blue, azo pigments, phthalocyanine pigments, quinacridone pigments, isoindoline pigments, threne pigments, perylene pigments, and the like.

[0206]

Examples of effect pigments include aluminum powder, mica powder, titanium oxide-coated mica powder, and the like.

[0207]

Examples of extender pigments include talc, clay, kaolin, baryta, barium sulfate, barium carbonate, calcium carbonate, alumina white, and the like.

[0208]

The above pigments may be used singly, or in a combination of two or more.

[0209]

When the paint composition of the present invention is used as a clear paint and contains a pigment, the pigment is preferably used in such an amount that the transparency of the resulting coating film is not impaired. For example, the amount of the pigment is generally within the range of 0.1 to 20 mass%, preferably 0.3 to 10 mass%, and more preferably 0.5 to 5 mass%, based on the total solids content in the paint composition.

[0210]

When the paint composition of the present invention is used as colored paint and contains a pigment, the amount of the pigment is generally within the range of 1 to 200 mass%, preferably 2 to 100 mass%, and more preferably 5 to 50 mass%, based on the total solids content in the paint composition.

[0211]

"Solids content" as used herein refers to the non-volatile components of the resin, curing agent, pigment, and the like remaining in the paint composition after drying the paint composition at 110°C for 1 hour. For example, the total solids content of the paint composition can be calculated as follows. The paint composition is measured in a heat-resistant container such as an aluminum foil cup, spread at the bottom of the container, and then dried at 110°C for 1 hour, after which the mass of the components in the paint composition remaining after drying is measured to determine the ratio of the mass of the components remaining after drying with respect to the total mass of the paint composition before drying.

[0212]

Examples of ultraviolet absorbers include known ultraviolet absorbers, such as benzotriazole absorbers, triazine absorbers, salicylic acid derivative absorbers, benzophenone absorbers, and like ultraviolet absorbers. These ultraviolet absorbers may be used singly, or in a combination of two or more.

[0213]

When the paint composition of the present invention contains an ultraviolet absorber, the amount of the ultraviolet absorber is generally within the range of 0.1 to 10 mass%, preferably 0.2 to 5 mass%, and more preferably 0.3 to 2 mass%, based on the total solids content in the paint composition.

[0214]

Examples of light stabilizers include known light stabilizers, such as hindered amine light stabilizers.

[0215]

The hindered amine light stabilizer for use is preferably a hindered amine light stabilizer having low basicity from the viewpoint of the pot life. Examples of such hindered amine light stabilizers include acylated hindered amines, amino ether-based hindered amines, and the like. Specific examples include HOSTAVIN 3058 (trade name, produced by Clariant), TINUVIN 123 (trade name, produced by BASF), and the like.

[0216]

When the paint composition of the present invention contains a light stabilizer, the amount of the light stabilizer is generally within the range of 0.1 to 10 mass%, preferably 0.2 to 5 mass%, and more preferably 0.3 to 2 mass%, based on the total solids content in the paint composition.

[0217]

Examples of catalysts include known catalysts. For example, when the paint composition of the present invention contains the polyisocyanate compound and/or blocked polyisocyanate compound mentioned above as the crosslinking agent (A2), the paint composition of the present invention may contain a urethanization reaction catalyst.

[0218]

Specific examples of urethanization reaction catalysts include organometallic compounds, such as tin octylate, dibutyltin diacetate, dibutyltin di(2-ethylhexanoate), dibutyltin dilaurate, dioctyltin diacetate, dioctyltin di(2-ethylhexanoate), dibutyltin oxide, dibutyltin sulfide, dioctyltin oxide, dibutyltin fatty acid salts, lead 2-ethylhexanoate, zinc octylate, zinc naphthenate, zinc fatty acid salts, bismuth octanoate, bismuth 2-ethylhexanoate, bismuth oleate, bismuth neodecanoate, bismuth versatate, bismuth naphthenate, cobalt naphthenate, calcium octylate, copper naphthenate, and tetra(2-ethylhexyl)titanate; tertiary amine; and the like. These may be used singly, or in a combination of two or more.

[0219]

When the paint composition of the present invention contains a urethanization reaction catalyst described above, the amount of the urethanization reaction catalyst is preferably within the range of 0.005 to 2 mass%, and more preferably 0.01 to 1 mass%, based on the total solids content in the paint composition of the present invention.

[0220]

When the paint composition of the present invention contains a urethanization reaction catalyst described above, the paint composition of the present invention may contain acetic acid, propionic acid, butyric acid, isopentanoic acid, hexanoic acid, 2-ethylbutyric acid, naphthenic acid, octylic acid, nonanoic acid, decanoic acid, 2-ethylhexanoic acid, isooctanoic acid, isononanoic acid, lauric acid, palmitic acid, stearic acid, oleic acid, linoleic acid, neodecanoic acid, versatic acid, isobutyric anhydride, itaconic anhydride, acetic anhydride, citraconic anhydride, propionic anhydride, maleic anhydride, butyric anhydride, citric anhydride, trimellitic anhydride, pyromellitic anhydride, phthalic anhydride, or like organic acid; hydrochloric acid, phosphoric acid, or like inorganic acid; acetylacetone, an imidazole compound, or like metal coordination compound; or the like, from the viewpoint of storage stability, curability, or the like.

[0221]

When a melamine resin described above is used as the crosslinking agent (A2) in the paint composition of the present invention, the paint composition of the present invention may contain, as a curing catalyst, p-toluenesulfonic acid, dodecylbenzenesulfonic acid, dinonylnaphthalene sulfonic acid, or like sulfonic acid; monobutyl phosphate, dibutyl phosphate, mono(2-ethylhexyl) phosphate, di(2-ethylhexyl) phosphate, or like alkyl phosphoric esters; a salt of such an acid with an amine compound; or the like.

[0222]

When the paint composition of the present invention contains a curing catalyst for the melamine resin, the amount of the curing catalyst for the melamine resin is preferably within the range of 0.1 to 2 mass%, more preferably 0.2 to 1.7 mass%, and still more preferably 0.3 to 1.4 mass%, based on the total solids content in the paint composition of the present invention.

[0223]

The substrate to be coated with the paint composition of the present invention is not particularly limited. Examples of the substrates include exterior panel parts of automotive bodies such as for passenger cars, trucks, motorcycles, and buses; automotive parts; exterior panel parts of household electric appliances such as cellular phones and audio equipment; and the like. The exterior panel parts of automotive bodies and automotive parts are particularly preferable.

[0224]

The material for the substrate is not particularly limited. Examples include metallic materials, such as iron, aluminum, brass, copper, tin plate, stainless steel, galvanized steel, steel plated with a zinc alloy (Zn-Al, Zn-Ni, Zn-Fe, or the like); plastic materials, such as polyethylene resins, polypropylene resins, acrylonitrile-butadiene-styrene (ABS) resins, polyamide resins, acrylic resins, vinylidene chloride resins, polycarbonate resins, polyurethane resins, epoxy resins, and like resins, and various types of FRP; inorganic materials, such as glass, cement, and concrete; wood; textile materials (e.g., paper and cloth); and the like. Of these materials, metallic materials and plastic materials are preferable.

[0225]

The substrate may be a metallic material mentioned above or a vehicle body etc. formed from a metallic material mentioned above that has been subjected to a surface treatment, such as a phosphoric acid salt treatment, chromate treatment, or composite oxide treatment. The substrate may also be a metallic material, vehicle body, or the like mentioned above on which an undercoating film of various electrodeposition paint has been formed. The substrate may also be a metallic material, vehicle body, or the like mentioned above on which an undercoating film of various electrodeposition paint has been formed, and an intermediate coating film has been further formed on the undercoating film. The substrate may also be a plastic material, such as a bumper, on which a primer coating film has been formed.

[0226]

The method of applying a paint containing the paint composition of the present invention (hereinafter sometimes simply referred to as "the paint of the present invention") is not particularly limited. For example, air spray coating, airless spray coating, rotary atomization coating, curtain coating, or other coating methods can be used to form a wet coating film. In these coating methods, an electrostatic charge may be applied, if necessary. Of these methods, air spray coating or rotary atomization coating is particularly preferred. The paint of the present invention is generally preferably applied to a cured film thickness of 10 to 60 µm, and more preferably 25 to 55 µm. In particular, the cured film thickness is preferably 35 to 55 µm, and particularly preferably 41 to 50 µm.

[0227]

When air spray coating, airless spray coating, or rotary atomization coating is performed, it is preferred that the paint of the present invention be appropriately adjusted in advance by adding a solvent, such as an organic solvent, to have a viscosity suitable for coating, which is generally from 15 to 60 seconds, and preferably 20 to 40 seconds, as measured with a Ford Cup No. 4 viscometer at 20°C.

[0228]

The wet coating film obtained by applying the paint of the present invention to a substance can be cured by heating. Heating can be performed by known heating means. For example, a drying furnace, such as a hot air furnace, an electric furnace, or an infrared induction heating furnace, can be used. The heating temperature is not particularly limited, and is, for example, within the range of 60 to 160°C, and preferably 80 to 140°C. The heating time is not particularly limited, and is, for example, within the range of 10 to 60 minutes, and preferably 15 to 30 minutes.

[0229]

The paint of the present invention, which is a paint composition capable of forming a coating film that has both excellent water blushing resistance and finished appearance, can be suitably used, in particular, as top clear coat paint. The paint of the present invention can be suitably used as paint for, in particular, automobiles.

[0230]

Method for forming multilayer coating film

The method for forming a multilayer coating film in which the paint of the present invention is applied as top clear coat paint may be a method for forming a multilayer coating film comprising sequentially forming on a substrate at least one layer of colored base coat paint and at least one layer of clear coat paint, wherein the paint composition of the present invention is applied as the clear coat paint for forming the uppermost layer.

[0231]

Specific examples of such a method include a method for forming a multilayer coating film by a 2-coat 1-bake method, in which colored base coat paint is applied to a substrate onto which an electrodeposition coating film and/or intermediate coating film has been applied, the resulting uncured coating film is, as necessary, preheated at, for example, 40 to 90°C for about 3 to 30 minutes to accelerate the vaporization of the solvent in the colored base coat paint, and the paint of the present invention is then applied as clear coat paint to the uncured colored base coating film, followed by simultaneous curing of the colored base coating film and the clear coating film.

[0232]

The paint of the present invention can also be suitably used as top clear coat paint for top-coating in a 3-coat 2-bake method or a 3-coat 1-bake method.

[0233]

The base coat paint used in the above manner may be a commonly known thermosetting base coat paint. Specific examples include paints obtained by appropriately combining a crosslinking agent, such as an amino resin, a polyisocyanate compound, or a blocked polyisocyanate compound, with reactive functional groups of a base resin, such as an acrylic resin, a polyester resin, an alkyd resin, or a urethane resin.

[0234]

As the base coat paint, for example, aqueous paint, organic solvent-based paint, or powder paint can also be used. From the viewpoint of the finished appearance of the coating film and a reduction in the environmental load, aqueous paint is preferable.

[0235]

When two or more clear coating films are formed in the method for forming a multilayer coating film, the paint of the present invention or known thermosetting clear coat paint may be used as clear coat paint for forming a layer other than the uppermost layer.

Examples

[0236]

The present invention is described below in more detail with reference to Production Examples, Examples, and Comparative Examples. However, the present invention is not limited to these. In each example, parts and percentages are expressed on a mass basis unless otherwise specified, and the film thickness is the thickness of a cured coating film.

[0237]

Production of hydroxy-containing acrylic resin (A1-1-1)

Production Example 1

27 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent) and 5 parts of propylene glycol monomethyl ether acetate were placed in a reaction vessel equipped with a thermometer, a thermostat, a stirrer, a reflux condenser, a nitrogen inlet tube, and a dropping funnel. While blowing nitrogen gas into the reaction vessel, the mixture was stirred at 150°C. A monomer mixture comprising 20 parts of styrene, 32.5 parts of 2-hydroxypropyl acrylate, 46.5 parts of isobutyl methacrylate, 1.0 part of acrylic acid, and 1.5 parts of ditertiary amyl peroxide (polymerization initiator) was added thereto dropwise at a constant rate over a period of 4 hours. The resulting mixture was then aged at 150°C for 1 hour, cooled, and further diluted with the addition of 34 parts of butyl acetate, thereby obtaining a hydroxy-containing acrylic resin (A1-1-1) solution having a solids concentration of 60 mass%. The obtained hydroxy-containing acrylic resin (A1-1-1) had a hydroxy value of 140 mg KOH/g, an acid value of 8.0 mg KOH/g, a weight average molecular weight of 10000, and a glass transition temperature of 39°C.

[0238]

Production of hydroxy-containing acrylic resin (A1-1-2)

Production Example 2

30 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent) and 10 parts of n-butanol were placed in a reaction vessel equipped with a thermometer, a thermostat, a stirrer, a reflux condenser, a nitrogen inlet tube, and a dropping funnel. While blowing nitrogen gas into the reaction vessel, the mixture was stirred at 125°C. A monomer mixture comprising 30 parts of γ-methacryloxypropyltrimethoxysilane, 32.5 parts of 2-hydroxypropyl acrylate, 20 parts of styrene, 17.5 parts of isobutyl methacrylate, and 7.0 parts of 2,2′-azobis(2-

methylbutyronitrile) (polymerization initiator) was added thereto dropwise at a constant rate over a period of 4 hours. The resulting mixture was then aged at 125°C for 30 minutes, and a solution containing 0.5 parts of 2,2′-azobis(2-methylbutyronitrile) and 5.0 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent) was added thereto dropwise at a constant rate over 1 hour. The resulting mixture was then aged at 125°C for 1 hour, cooled, and further diluted with the addition of 8 parts of isobutyl acetate, thereby obtaining a hydroxy-containing acrylic resin (A1-1-2) solution (secondary hydroxy- and alkoxysilyl-containing acrylic resin solution) having a solids concentration of 65 mass%. The obtained hydroxy-containing acrylic resin (A1-1-2) had an alkoxysilyl group content of 1.21 mmol/g, a hydroxy value of 140 mg KOH/g, a weight average molecular weight of 7000, and a glass transition temperature of 18°C.

Production of hydroxy-containing acrylic resin (A1-1-3)

Production Example 3

30 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent) and 10 parts of n-butanol were placed in a reaction vessel equipped with a thermometer, a thermostat, a stirrer, a reflux condenser, a nitrogen inlet tube, and a dropping funnel. While blowing nitrogen gas into the reaction vessel, the mixture was stirred at 125°C. A monomer mixture comprising 30 parts of γ-methacryloxypropyltrimethoxysilane, 32.5 parts of 2-hydroxyethyl methacrylate, 20 parts of styrene, 17.5 parts of isobutyl methacrylate, and 7.0 parts of 2,2'-azobis(2-methylbutyronitrile) (polymerization initiator) was added thereto dropwise at a constant rate over a period of 4 hours. The resulting mixture was then aged at 125°C for 30 minutes, and a solution containing 0.5 parts of 2,2'-azobis(2-methylbutyronitrile) and 5.0 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent) was added thereto dropwise at a

constant rate over 1 hour. The resulting mixture was then aged at 125°C for 1 hour, cooled, and further diluted with the addition of 8 parts of isobutyl acetate, whereby obtaining a hydroxy-containing acrylic resin (A1-1-3) solution (primary hydroxy- and alkoxysilyl-containing acrylic resin solution) having a solids concentration of 65 mass%. The obtained hydroxy-containing acrylic resin (A1-1-3) had an alkoxysilyl group content of 1.21 mmol/g, a hydroxy value of 140 mg KOH/g, a weight average molecular weight of 7000, and a glass transition temperature of 39°C.

[0239]

Production of first rheology control agent (B)

Production Example 4

150 parts (solids content: 90 parts) of the hydroxy-containing acrylic resin (A1-1-1) solution obtained in Production Example 1, 17 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent), and 10 parts of n-butanol were placed in a reaction vessel equipped with a stirrer and a dropping funnel. Then, an amine mixture comprising 5.44 parts of benzylamine and 0.20 parts of JEFFAMINE D-400 (trade name, produced by Huntsman Corporation, a polyoxypropylene-containing diamine, number average molecular weight: 400) was added thereto with stirring at room temperature. Subsequently, a mixture of 4.36 parts of hexamethylene diisocyanate and 13 parts of butyl acetate was added dropwise with stirring, to thereby obtain a first rheology control agent dispersion (BM-1). The obtained first rheology control agent dispersion (BM-1) had a solids content of 50%. In the obtained first rheology control agent dispersion (BM-1), the total mass of the components (b1) to (b3) was 10 parts by mass, the mass of the hydroxy-containing acrylic resin (A1-1-1), which is a resin component, was 90 parts by mass, and the ratio of (the total mass of the components (b1) to (b3))/(the mass of the resin component) was 10/90.

[0240]

Production Examples 5 to 11

First rheology control agent dispersions (BM-2) to (BM-8) were obtained in the same manner as in Production Example 4, except that the formulations shown in Table 1 were used. The obtained first rheology control agent dispersions (BM-2) to (BM-8) had a solids content of 50%. The amounts of the components shown in Table 1 are expressed as solids content by mass.

[0241]

Table 1

Production Example					4	5	6	7
Rheology control agent dispersion name					BM-1	BM-2	BM-3	BM-4
Resin component	Hydroxy-containing resin (A1)		Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1)	90	90	95	90
Rheology control agent (B)	Amine mixture	Primary monoamine having a number average molecular weight of 300 or less (b2)	Benzylamine		5.44	5.28	2.64	4.97
		Polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3)	Polyoxyalkylene chain-containing diamine	JEFFAMINE D-400	0.2	0.4	0.2	0.8
	Polyisocyanate compound (b1)		Aliphatic polyisocyanate compound	Hexamethylene diisocyanate	4.36	4.32	2.16	4.23
Proportion of each component based on the total mass of components (b1) to (b3) (mass%)			Polyisocyanate compound (b1)		43.6	43.2	43.2	42.3
			Primary monoamine having a number average molecular weight of 300 or less (b2)		54.4	52.8	52.8	49.7
			Polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3)		2	4	4	8
Total mass of components (b1) to (b3)					10	10	5	10
Mass of resin component					90	90	95	90
(Total mass of components (b1) to (b3))/(mass of resin component) ratio					10/90	10/90	5/95	10/90

[0242]

Table 1 (continued-1)

Production Example					8	9	10	11
Rheology control agent dispersion name					BM-5	BM-6	BM-7	BM-8
Resin component	Hydroxy-containing resin (A1)		Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1)	90	90	90	90
Rheology control agent (B)	Amine mixture	Primary monoamine having a number average molecular weight of 300 or less (b2)	Benzylamine		5.36	5.36	5.37	5.36
		Polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3)	Polyoxyalkylene chain-containing diamine	JEFFAMINE D-2000 (*1)	0.4			
			Polyoxyalkylene chain-containing triamine	JEFFAMINE T-3000 (*2)		0.4		
				JEFFAMINE T-5000 (*3)			0.4	
			Polyoxyalkylene chain-containing monoamine	JEFFAMINE M-1000 (*4)				0.4
	Polyisocyanate compound (b1)		Aliphatic polyisocyanate compound	Hexamethylene diisocyanate	4.24	4.24	4.23	4.24
Proportion of each component based on the total mass of components (b1) to (b3) (mass%)			Polyisocyanate compound (b1)		42.4	42.4	42.3	42.4
			Primary monoamine having a number average molecular weight of 300 or less (b2)		53.6	53.6	53.7	53.6
			Polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3)		4	4	4	4
Total mass of components (b1) to (b3)					10	10	10	10
Mass of resin component					90	90	90	90
(Total mass of components (b1) to (b3))/(mass of resin component) ratio					10/90	10/90	10/90	10/90

[0243]

The asterisks (*) in Table 1 mean the following.

*1: JEFFAMINE D-2000: trade name, produced by Huntsman Corporation, polyoxyalkylene-containing diamine, a number average molecular weight of 2000

*2: JEFFAMINE T-3000: trade name, produced by Huntsman Corporation, polyoxyalkylene-containing triamine, a number average molecular weight of 3000

*3: JEFFAMINE T-5000: trade name, produced by Huntsman Corporation, polyoxyalkylene-containing triamine, a number average molecular weight of 5000

*4: JEFFAMINE M-1000: trade name, produced by Huntsman Corporation, polyoxyalkylene-containing monoamine, a number average molecular weight of 1000

[0244]

Production of second rheology control agent (C)

Production Example 12

158.3 parts (solids content: 95.0 parts) of the hydroxy-containing acrylic resin (A1-1-1) solution obtained in Production Example 1, 15.2 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent), and 10 parts of n-butanol were placed in a reaction vessel equipped with a stirrer and a dropping funnel. Then, an amine mixture comprising 2.44 parts of benzylamine and 0.6 parts of JEFFAMINE D-2000 (trade name, produced by Huntsman Corporation, a polyoxypropylene-containing diamine, number average molecular weight: 2000) was added thereto with stirring at room temperature. Subsequently, a mixture of 1.96 parts of hexamethylene diisocyanate and 11.5 parts of Swasol 1000 (trade name, produced by Cosmo Oil Co., Ltd., an aromatic organic solvent) was added dropwise with stirring, to thereby obtain a rheology control agent dispersion (CM-1). The obtained rheology control agent dispersion (CM-1) had a solids content of 50%. In the obtained rheology control agent dispersion (CM-1), the total mass of the components (c1) to (c3) was 5.0 parts by mass, the mass of the hydroxy-containing acrylic resin (A1-1-1), which is a resin component, was 95.0 parts by mass, and the ratio of (the total mass of the components (c1) to (c3))/(the mass of the resin component) was 5/95.

[0245]

Production Examples 13 to 20

Second rheology control agent dispersions (CM-2) to (CM-9) were obtained in the same manner as in Production Example

12, except that the formulations shown in Table 2 were used. The obtained second rheology control agent dispersions (CM-2) to (CM-9) had a solids content of 50%. The amounts of the components shown in Table 2 are expressed as solids content by mass.

[0246]

Table 2

Production Example					12	13	14	15	16
Rheology control agent dispersion name					CM-1	CM-2	CM-3	CM-4	CM-5
Resin component	Hydroxy-containing resin (A1)		Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	95	95	95	95	95
Rheology control agent (C)	Amine mixture	Primary monoamine having a number average molecular weight of 300 or less (c2)	Benzylamine		2.44	2.19	2.44	2.19	
			Octylamine						2.35
		Polyether amine having two or more amino groups and a number average molecular weight of 1000 or more and less than 6000 (c3)	Polyoxyalkylene chain-containing diamine	JEFFAMINE D-2000	0.6	1.0			
			Polyoxyalkylene chain-containing triamine	JEFFAMINE T-3000 (*2)			0.6	1.0	1.0
	Polyisocyanate compound (c1)		Aliphatic polyisocyanate compound	Hexamethylene diisocyanate	1.96	1.81	1.96	1.81	1.65
Proportion of each component based on the total mass of components (c1) to (c3) (mass%)			Polyisocyanate compound(c1)		39.3	36.1	39.3	36.1	33.1
			Primary monoamine having a number average molecular weight of 300 or less (c2)		48.7	43.9	48.7	43.9	46.9
			Polyether amine having two or more amino groups and a number average molecular weight of 1000 or more and less than 6000 (c3)		12	20	12	20	20
Total mass of components (c1) to (c3)					5.0	5.0	5.0	5.0	5.0
Mass of resin component					95.0	95.0	95.0	95.0	95.0
(Total mass of components (c1) to (c3))/(mass of resin component) ratio					5/95	5/95	5/95	5/95	5/95

[0247]

Table 2 (continued-1)

Production Example					17	18	19	20
Rheology control agent dispersion name					CM-6	CM-7	CM-8	CM-9
Resin component	Hydroxy-containing resin (A1)		Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	97.5	95	95	95
Rheology control agent (C)	Amine mixture	Primary monoamine having a number average molecular weight of 300 or less (c2)	Benzylamine		1.1	1.95	2.19	2.21
		Polyether amine having two or more amino groups and a number average molecular weight of 1000 or more and less than 6000 (c3)	Polyoxyalkylene chain-containing diamine	JEFFAMINE D-2000			0.50	
			Polyoxyalkylene chain-containing triamine	JEFFAMINE T-3000 (*2)	0.5	1.4	0.50	
				JEFFAMINE T-5000 (*3)				1.0
	Polyisocyanate compound (c1)		Aliphatic polyisocyanate compound	Hexamethylene diisocyanate	0.9	1.65	1.81	1.79
Proportion of each component based on the total mass of components (c1) to (c3) (mass%)			Polyisocyanate compound (c1)		36.0	33.0	36.1	35.7
			Primary monoamine having a number average molecular weight of 300 or less (c2)		44.0	39.0	43.9	44.3
			Polyether amine having two or more amino groups and a number average molecular weight of 1000 or more and less than 6000 (c3)		20	28	20	20
Total mass of components (c1) to (c3)					2.5	5.0	5.0	5.0
Mass of resin component					97.5	95	95	95
(Total mass of components (c1) to (c3))/(mass of resin component) ratio					2.5/97.5	5/95	5/95	5/95

[0248]

Production of paint composition: Part 1

Example 1

84.5 parts (solids content: 50.7 parts) of the hydroxy-containing acrylic resin (A1-1-1) solution obtained in Production Example 1, 6.7 parts (solids content: 4 parts) of U-VAN 20SE60 (trade name, produced by Mitsui Chemicals, Inc., a melamine resin, solids content: 60%), 6 parts (solids content: 3 parts, in which the rheology control agent (B) component makes up 0.3 parts, and the hydroxy-containing acrylic resin (A1-1-1) makes up 2.7 parts) of the first rheology control agent dispersion (BM-1) solution obtained in Production Example 4, 16 parts (solids content: 8 parts, in which the rheology control agent (C) component makes up 0.4 parts, and the hydroxy-containing acrylic resin (A1-1-1) makes up 7.6 parts) of the second rheology control agent dispersion (CM-1) solution obtained in Production Example 12, 0.4 parts (solids content: 0.2 parts) of BYK-300 (trade name, produced by BYK-Chemie, a surface-adjusting agent, active ingredient: 52%), and 0.3 parts (solids content: 0.1 parts) of NACURE 5523 (trade name, amine salt of dodecylbenzenesulfonic acid, catalyst, active ingredient: 35%, produced by King Industries, Inc.) were uniformly mixed to obtain a main agent.

The main agent and 35 parts of Sumidur N3300 (trade name, produced by Sumika Covestro Urethane Co., Ltd., an isocyanurate of hexamethylene diisocyanate, solids content: 100%), which is a curing agent (crosslinking agent (A2)), were uniformly mixed immediately before application; and butyl acetate was further added thereto to adjust the viscosity to 30 seconds as measured with a Ford Cup No. 4 at 20°C, thereby obtaining paint composition No. 1.

[0249]

Examples 2 to 25 and Comparative Examples 1 to 4

Paint compositions No. 2 to 29 with a viscosity of 30 seconds as measured with a Ford Cup No. 4 at 20°C were obtained in the same manner as in Example 1, except that the formulations shown in Table 3 below were used. The amounts of the components shown in Table 3 are expressed as solids content by mass.

[0250]

Preparation of test panel: Part 1

Preparation of test panel for Examples 1 to 25 and Comparative Examples 1 to 4

Preparation of test panel for evaluation of finished appearance and water blushing resistance

Elecron GT-10 (trade name, produced by Kansai Paint Co., Ltd., cationic electrodeposition paint) was applied by electrodeposition to a cold-rolled steel plate (10 cm × 15 cm) treated with zinc phosphate to a dry film thickness of 20 μm, and cured by heating at 170°C for 30 minutes. Thereafter, WP-306T (trade name, produced by Kansai Paint Co., Ltd., polyester melamine resin-based aqueous intermediate paint) was electrostatically applied to the electrodeposition coating film by using a rotary atomization electrostatic coating machine to a cured film thickness of 30 µm and allowed to stand for 5 minutes, followed by preheating at 80°C for 3 minutes and then heating at 140°C for 30 minutes, thereby preparing a test substrate. Subsequently, WBC-713T No. 202 (trade name, produced by Kansai Paint Co., Ltd., acrylic melamine resin-based aqueous base coat paint, coating color: black) was electrostatically applied to the test substrate held upright by using a rotary atomization electrostatic coating machine to a cured film thickness of 15 µm. The resulting test substrate was allowed to stand for 5 minutes, and then preheated in an upright state at 80°C for 3 minutes. Subsequently, paint composition No. 1 was electrostatically applied to the uncured base coating film in an upright state by using a rotary atomization electrostatic coating machine to a dry film thickness of 45 µm to form a clear coating film. The resulting product was allowed to stand for 7 minutes and heated at 140°C for 30 minutes (keeping time) in an upright state to cure the base coating film and the clear coating film, thereby preparing a test panel of Example 1.

[0251]

Test panels of paint compositions No. 2 to 29 were prepared in the same manner as in the preparation of test panel of paint composition No. 1, except that paint compositions No. 2 to 29 were each used.

[0252]

Preparation of test panel for evaluation of sag resistance

Elecron GT-10 (trade name, produced by Kansai Paint Co., Ltd., cationic electrodeposition paint) was applied by electrodeposition to a cold-rolled steel plate (11 cm × 45 cm) treated with zinc phosphate to a dry film thickness of 20 µm, and cured by heating at 170°C for 30 minutes. Thereafter, WP-306T (trade name, produced by Kansai Paint Co., Ltd., polyester melamine resin-based aqueous intermediate paint) was electrostatically applied to the electrodeposition coating film by using a rotary atomization electrostatic coating machine to a cured film thickness of 30 µm and allowed to stand for 5 minutes, followed by preheating at 80°C for 3 minutes and then heating at 140°C for 30 minutes, thereby preparing a test substrate. Subsequently, 21 punch holes with a diameter of 5 mm were formed in a row at 2-cm intervals at a distance 3 cm away from the edge on a longitudinal side of the test substrate. Subsequently, WBC-713T No. 202 (trade name, produced by Kansai Paint Co., Ltd., acrylic melamine resin-based aqueous base coat paint, coating color: black) was electrostatically applied to the test substrate held upright by using a rotary atomization electrostatic coating machine to a cured film thickness of 15 µm. The resulting test substrate was allowed to stand for 5 minutes, and preheated in an upright state at 80°C for 3 minutes. Thereafter, paint composition No. 1 was applied to the uncured coating film in an upright state by using a rotary atomization electrostatic coating machine to a film thickness of approximately 30 µm to 60 µm with a gradient in the longitudinal direction. The resulting product was allowed to stand for 7 minutes at room temperature and heated at 140°C for 30 minutes (keeping time) in an upright state to cure the base coating film and the clear coating film, thereby preparing a test panel of Example 1.

[0253]

Test panels of paint compositions No. 2 to 29 were prepared in the same manner as in the preparation of test panel of paint composition No. 1, except that paint compositions No. 2 to 29 were each used.

[0254]

The test panels obtained above were each evaluated by the test methods described below. Table 3 shows the evaluation results together with the formulations of the paint compositions.

[0255]

Test method

Finished appearance: The finished appearance of each test panel was evaluated based on a long wave (LW) value measured by using Wave Scan (trade name, produced by BYK Gardner). The smaller the LW value, the higher the smoothness of the coating surface.

[0256]

Water blushing resistance: The water blushing resistance of each test panel was evaluated based on a difference in L^* values measured with a CM-512m3 (trade name, produced by Konica Minolta, Inc., a multi-angle spectrophotometer) before and after immersion in hot water. In this test, the L* value was a value obtained by summing the L* values obtained when the panel was illuminated with standard illuminant D65 from three angles, i.e., 25° (highlight direction), 45°, and 75° (bottom direction), relative to the receiving angle (the direction perpendicular to the coated surface was regarded as 0°). After the L^* values were measured, the test panel was immersed in hot water at 40°C for 10 days, the L^* values of the test panel after immersion were measured, and the difference ΔL^* between the L^* values before and after immersion was calculated. A smaller ΔL^* value indicates less blushing of the coating due to hot-water immersion, and represents higher water blushing resistance.

[0257]

Sag resistance: Each test panel was examined to determine the portions where 3 mm sagging of the coating composition was observed from the lower end of each punch hole. The sag resistance was evaluated by measuring the film thickness (sagging-limit film thickness (μm)) at these portions. The larger the sagging-limit film thickness, the better the sag resistance.

[0258]

Table 3

					Example					
					1	2	3	4	5	6
Paint composition No.					1	2	3	4	5	6
Main agent	Binder component (A)	Hydroxy-containing resin (A1)	Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	50.7	50.7	50.7	50.7	50.7	50.7
		Crosslinking agent (A2)	Amino resin	U-VAN 20SE60	4	4	4	4	4	4
	First rheology control agent dispersion			Name	BM-1	BM-2	BM-2	BM-2	BM-2	BM-2
				Amount	3	3	3	3	3	3
	Second rheology control agent dispersion			Name	CM-1	CM-1	CM-2	CM-3	CM-4	CM-5
				Amount	8	8	8	8	8	8
	Surface-adjusting agent			BYK-300	0.2	0.2	0.2	0.2	0.2	0.2
	Catalyst			NACURE 5523	0.1	0.1	0.1	0.1	0.1	0.1
Curing agent	Binder component (A)	Crosslinking agent (A2)	Polyisocyanate compound	Sumidur N3300	35	35	35	35	35	35
Content of components (A), (B), and (C) (parts by mass)	Binder component (A)	Hydroxy-containing resin (A1)			61	61	61	61	61	61
		Crosslinking agent (A2)			39	39	39	39	39	39
	First rheology control agent (B)				0.3	0.3	0.3	0.3	0.3	0.3
	Second rheology control agent (C)				0.4	0.4	0.4	0.4	0.4	0.4
Evaluation results	Finished appearance (LW)				6.0	5.8	5.5	5.6	4.6	4.6
	Sag resistance				52	53	54	54	55	54
	Water blushing resistance (ΔL*)				0.4	0.4	0.3	0.3	0.2	0.2

[0259]

Table 3 (continued-1)

					Example				
					7	8	9	10	11
Paint composition No.					7	8	9	10	11
Main agent	Binder component (A)	Hydroxy-containing resin (A1)	Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	42.7	46.7	46.7	40.0	27.1
		Crosslinking agent (A2)	Amino resin	U-VAN 20SE60	4		35	4	4
	First rheology control agent dispersion			Name	BM-2	BM-2	BM-2	BM-2	BM-2
				Amount	3	3	3	6	3
	Second rheology control agent dispersion			Name	CM-6	CM-6	CM-6	CM-6	CM-6
				Amount	16	16	16	16	32
	Surface-adjusting agent			BYK-300	0.2	0.2	0.2	0.2	0.2
	Catalyst			NACURE 5523	0.1		0.1	0.1	0.1
Curing agent	Binder component (A)	Crosslinking agent (A2)	Polyisocyanate compound	Sumidur N3300	35	35		35	35
Content of components (A), (B), and (C) (parts by mass)	Binder component (A)	Hydroxy-containing resin (A1)			61	65	65	61	61
		Crosslinking agent (A2)			39	35	35	39	39
	First rheology control agent (B)				0.3	0.3	0.3	0.6	0.3
	Second rheology control agent (C)				0.4	0.4	0.4	0.4	0.8
Evaluation results	Finished appearance (LW)				4.5	4.7	4.6	5.0	4.8
	Sag resistance				56	56	55	57	58
	Water blushing resistance (ΔL*)				0.2	0.2	0.2	0.4	0.3

[0260]

Table 3 (continued-2)

					Example				
					12	13	14	15	16
Paint composition No.					12	13	14	15	16
Main agent	Binder component (A)	Hydroxy-containing resin (A1)	Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	24.4	50.7	50.7	50.7	39.7
		Crosslinking agent (A2)	Amino resin	U-VAN 20SE60	4	4	4	4	4
	First rheology control agent dispersion			Name	BM-2	BM-2	BM-2	BM-2	BM-3
				Amount	6	3	3	3	6
	Second rheology control agent dispersion			Name	CM-6	CM-7	CM-8	CM-9	CM-6
				Amount	32	8	8	8	16
	Surface-adjusting agent			BYK-300	0.2	0.2	0.2	0.2	0.2
	Catalyst			NACURE 5523	0.1	0.1	0.1	0.1	0.1
Curing agent	Binder component (A)	Crosslinking agent (A2)	Polyisocyanate compound	Sumidur N3300	35	35	35	35	35
Content of components (A), (B), and (C) (parts by mass)	Binder component (A)	Hydroxy-containing resin (A1)			61	61	61	61	61
		Crosslinking agent (A2)			39	39	39	39	39
	First rheology control agent (B)				0.6	0.3	0.3	0.3	0.3
	Second rheology control agent (C)				0.8	0.4	0.4	0.4	0.4
Evaluation results	Finished appearance (LW)				5.1	4.7	5.0	5.2	4.6
	Sag resistance				59	56	56	54	55
	Water blushing resistance (ΔL*)				0.5	0.2	0.3	0.3	0.2

[0261]

Table 3 (continued-3)

					Example				
					17	18	19	20	21
Paint composition No.					17	18	19	20	21
Main agent	Binder component (A)	Hydroxy-containing resin (A1)	Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	42.7	42.7	42.7	42.7	42.7
		Crosslinking agent (A2)	Amino resin	U-VAN 20SE60	4	4	4	4	4
	First rheology control agent dispersion			Name	BM-4	BM-5	BM-6	BM-7	BM-8
				Amount	3	3	3	3	3
	Second rheology control agent dispersion			Name	CM-6	CM-6	CM-6	CM-6	CM-6
				Amount	16	16	16	16	16
	Surface-adjusting agent			BYK-300	0.2	0.2	0.2	0.2	0.2
	Catalyst			NACURE 5523	0.1	0.1	0.1	0.1	0.1
Curing agent	Binder component (A)	Crosslinking agent (A2)	Polyisocyanate compound	Sumidur N3300	35	35	35	35	35
Content of components (A), (B), and (C) (parts by mass)	Binder component (A)	Hydroxy-containing resin (A1)			61	61	61	61	61
		Crosslinking agent (A2)			39	39	39	39	39
	First rheology control agent (B)				0.3	0.3	0.3	0.3	0.3
	Second rheology control agent (C)				0.4	0.4	0.4	0.4	0.4
Evaluation results	Finished appearance (LW)				5.1	5.3	5.2	5.4	5.7
	Sag resistance				53	54	54	53	52
	Water blushing resistance (ΔL*)				0.3	0.4	0.4	0.5	0.6

[0262]

Table 3 (continued-4)

					Example			
					22	23	24	25
Paint composition No.					22	23	24	25
Main agent	Binder component (A)	Hydroxy-containing resin (A1)	Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	42.7	42.7	42.7	42.7
		Crosslinking agent (A2)	Amino resin	U-VAN 20SE60	4	4	4	4
	First rheology control agent dispersion			Name	BM-2	BM-2	BM-2	BM-2
				Amount	3	3	3	3
	Second rheology control agent dispersion			Name	CM-6	CM-6	CM-6	CM-6
				Amount	16	16	16	16
	Surface-adjusting agent			BYK-300	0.2	0.2	0.2	0.2
	Ultraviolet absorber			TINUVIN 400 (*5)	3	3	3	3
	Light stabilizer			HOSTAVIN 3058 (*6)	1	1	1	1
	Catalyst			NACURE 5523	0.1			
				NACURE 4167 (*7)		0.1		
				NEOSTANN U-600 (*8)			0.1	
Curing agent	Binder component (A)	Crosslinking agent (A2)	Polyisocyanate compound	Sumidur N3300	35	35	35	35
Content of components (A), (B), and (C) (parts by mass)	Binder component (A)	Hydroxy-containing resin (A1)			61	61	61	61
		Crosslinking agent (A2)			39	39	39	39
	First rheology control agent (B)				0.3	0.3	0.3	0.3
	Second rheology control agent (C)				0.4	0.4	0.4	0.4
Evaluation results	Finished appearance (LW)				4.6	4.7	4.6	4.8
	Sag resistance				55	55	56	54
	Water blushing resistance (ΔL*)				0.2	0.2	0.2	0.2

[0263]

Table 3 (continued-5)

					Comparative Example			
					1	2	3	4
Paint composition No.					26	27	28	29
Main agent	Binder component (A)	Hydroxy-containing resin (A1)	Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	58.3	47.5	34	61
		Crosslinking agent (A2)	Amino resin	U-VAN 20SE60	4	4	4	4
	First rheology control agent dispersion			Name	BM-2	BM-2	BM-2	
				Amount	3	15	30	
	Second rheology control agent dispersion			Name				
				Amount				
	Surface-adjusting agent			BYK-300	0.2	0.2	0.2	0.2
	Catalyst			NACURE 5523	0.1	0.1	0.1	0.1
Curing agent	Binder component (A)	Crosslinking agent (A2)	Polyisocyanate compound	Sumidur N3300	35	35	35	35
Content of components (A), (B), and (C) (parts by mass)	Binder component (A)	Hydroxy-containing resin (A1)			61	61	61	61
		Crosslinking agent (A2)			39	39	39	39
	First rheology control agent (B)				0.3	1.5	3.0	
	Second rheology control agent (C)							
Evaluation results	Finished appearance (LW)				11.5 (Sagging)	10.9 (Sagging)	10.1	7.8 (Sagging)
	Sag resistance				40	44	49	35
	Water blushing resistance (ΔL*)				0.2	1.4	2.2	0.0

[0264]

The asterisks (*) in Table 2 mean the following.

*5: TINUVIN 400: trade name, benzotriazole ultraviolet absorber, active ingredient: 100%, produced by BASF

*6: HOSTAVIN 3058: trade name, hindered amine light stabilizer, acylated hindered amine, active ingredient: 100%, produced by Clariant

*7: NACURE 4167: trade name, triethylamine salt of alkylphosphoric acid, curing catalyst for melamine resin, active ingredient: 25%, produced by King Industries, Inc.

*8: NEOSTANN U-600: trade name, inorganic bismuth, active ingredient: 100%, produced by Nitto Kasei Co., Ltd.

[0265]

Production of paint composition: Part 2

Example 26

34.5 parts (solids content: 20.7 parts) of the hydroxy-containing acrylic resin (A1-1-1) solution obtained in Production Example 1, 33.8 parts (solids content: 22 parts) of the hydroxy-containing acrylic resin (A1-1-2) solution obtained in Production Example 2, 6.7 parts (solids content: 4 parts) of U-VAN 20SE60 (trade name, produced by Mitsui Chemicals, Inc., a melamine resin, solids content: 60%), 6 parts (solids content: 3 parts, in which the rheology control agent (B) component makes up 0.3 parts, and the hydroxy-containing acrylic resin (A1-1-1) makes up 2.7 parts) of the rheology control agent dispersion (BM-2) solution obtained in Example 5, 32 parts (solids content: 16 parts, in which the rheology control agent (C) component makes up 0.4 parts, and the hydroxy-containing acrylic resin (A1-1-1) makes up 15.6 parts) of the rheology control agent dispersion (CM-6) solution obtained in Example 17, 0.4 parts (solids content: 0.2 parts) of BYK-300 (trade name, produced by BYK-Chemie, a surface-adjusting agent, active ingredient: 52%), and 0.3 parts (solids content: 0.1 parts) of NACURE 5523 (trade name, amine salt of dodecylbenzenesulfonic acid, catalyst, active ingredient: 35%, produced by King Industries, Inc.) were uniformly mixed to obtain a main agent. The main agent and 35 parts of Sumidur N3300 (trade name, produced by Sumika Covestro Urethane Co., Ltd., an isocyanurate of hexamethylene diisocyanate, solids content: 100%), which is a curing agent (crosslinking agent (A2)), were uniformly mixed immediately before application; and butyl acetate was further added thereto to adjust the viscosity to 30 seconds as measured with a Ford Cup No. 4 at 20°C, thereby obtaining paint composition No. 30.

[0266]

Examples 27 to 28 and Comparative Example 5

Paint compositions No. 31 to 33 with a viscosity of 30 seconds as measured with a Ford Cup No. 4 at 20°C were obtained in the same manner as in Example 26, except that the formulations shown in Table 3 below were used. The amounts of the components shown in Table 4 are expressed as solids content by mass.

[0267]

Preparation of test panel: Part 2

Preparation of test panel for Examples 26 to 28 and Comparative Example 5

Preparation of test panel for evaluation of finished appearance, water blushing resistance, and scratch resistance

Test panels of paint compositions No. 30 to 33 were prepared in the same manner as in the preparation of test panel for evaluation of finished appearance and water blushing resistance described in section "Preparation of test panel: Part 1," except that paint compositions No. 30 to 33 were each used.

[0268]

Preparation of test panel for evaluation of sag resistance

Test panels of paint compositions No. 30 to 33 were prepared in the same manner as in the preparation of test panel for evaluation of sag resistance in section "Preparation of test panel: Part 1," except that paint compositions No. 30 to 33 were each used.

[0269]

The test panels obtained above were each evaluated by the test methods described below. Table 4 shows the evaluation results together with the formulations of the paint compositions.

[0270]

Test method 2

The finished appearance, the water blushing resistance, and the sag resistance were evaluated in the same manner as described above in "Test method 1."

[0271]

Scratch resistance: Each test panel was attached to an automobile roof by using water-resistant adhesive tape (produced by Nichiban Co., Ltd.), and the automobile, which had the test panel on its roof, was washed 15 times in a car wash at 20°C. Thereafter, the 20° specular reflection (20° gloss) of the test panel was measured, and the gloss retention (%) relative to the 20° gloss value before the test was calculated to evaluate the scratch resistance. The higher the gloss retention, the better the scratch resistance. In this specification, an evaluation result of A, B, or C means excellent scratch resistance. The car wash used was a PO20 FWRC (produced by Yasui Sangyo K.K.).

A: Gloss retention of 80% or more

B: Gloss retention of 75% or more and less than 80%

C: Gloss retention of 70% or more and less than 75%

D: Gloss retention of 50% or more and less than 70%

E: Gloss retention of less than 50%

[0272]

Table 4

					Example			Comparative Example
					26	27	28	5
Paint composition No.					30	31	32	33
Main agent	Binder component (A)	Hydroxy-containing resin (A1)	Hydroxy-containing acrylic resin (A1-1)	Hydroxy-containing acrylic resin (A1-1-1)	20.7	10.7	20.7	36.3
				Secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1-2)	22	32		22
				Primary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1-3)			22	
		Crosslinking agent (A2)	Amino resin	U-VAN 20SE60	4	4	4	4
	First rheology control agent dispersion			Name	BM-2	BM-2	BM-2	BM-2
				Amount	3	3	3	3
	Second rheology control agent dispersion			Name	CM-6	CM-6	CM-6	
				Amount	16	16	16	
	Surface-adjusting agent			BYK-300	0.2	0.2	0.2	0.2
	Catalyst			NACURE 5523	0.1	0.1	0.1	0.1
Curing agent	Binder component (A)	Crosslinking agent (A2)	Polyisocyanate compound	Sumidur N3300	35	35	35	35
Content of components (A), (B), and (C) (parts by mass)	Binder component (A)	Hydroxy-containing acrylic resin (A1-1-1)			39	29	39	39
		Secondary hydroxy- and alkoxysilyl-containing acrylic resin (A1-1-2)			22	32	22	22
		Crosslinking agent (A2)			39	39	39	39
	First rheology control agent (B)				0.3	0.3	0.3	0.3
	Second rheology control agent (C)				0.4	0.4	0.4	
Evaluation results	Finished appearance (LW)				4.8	5.2	5.0	11.3 (Sagging)
	Sag resistance				54	55	53	40
	Water blushing resistance (ΔL*)				0.2	0.2	0.2	0.2
	Scratch resistance.				B	A	B	B

[0273]

The embodiments and Examples of the present invention are described in detail above. However, the present invention is not limited to these embodiments, and various modifications can be made based on the technical idea of the present invention.

[0274]

For instance, the structures, methods, steps, shapes, materials, and values stated in the embodiments and Examples above are merely examples, and different structures, methods, steps, shapes, materials, values, and the like may also be used, as necessary.

[0275]

Additionally, the structures, methods, steps, shapes, materials, values, and the like stated in the embodiments may be interchangeably combined without departing from the spirit and principal concepts of the present invention.

Furthermore, the present invention can also use the following structures.

[1] A paint composition comprising (A) a binder component, (B) a first rheology control agent, and (C) a second rheology control agent, wherein

the first rheology control agent (B) contains a reaction product of (b1) a polyisocyanate compound, (b2) a primary monoamine having a number average molecular weight of 300 or less, and (b3) a polyether amine having a number average molecular weight of more than 300 and less than 6000,

the proportion of the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) is 0.5 mass% or more and less than 10 mass% based on the total amount of the components (b1) to (b3),

the second rheology control agent (C) contains a reaction product of (c1) a polyisocyanate compound, (c2) a primary monoamine having a number average molecular weight of 300 or less, and (c3) a polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000, and

the proportion of the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) is within a range of 10 to 30 mass% based on the total amount of the components (c1) to (c3).

[2] The paint composition according to [1], wherein the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) has three or more amino groups.

[0276]

[3] The paint composition according to [1] or [2], wherein the proportion of the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) is more than 15 mass% and 30 mass% or less based on the total amount of the components (c1) to (c3).

[4] The paint composition according to any one of [1] to [3], wherein the proportion of the polyisocyanate compound (c1) is 30 mass% to 60 mass% based on the total amount of the components (c1) to (c3).

[5] The paint composition according to any one of [1] to [4], wherein the proportion of the primary monoamine having a number average molecular weight of 300 or less (c2) is 30 mass% to 60 mass% based on the total amount of the components (c1) to (c3).

[6] The paint composition according to any one of [1] to [5], wherein the proportion of the polyisocyanate compound (b1) is 30 mass% to 60 mass% based on the total amount of the component (b1) to (b3).

[7] The paint composition according to any one of [1] to [6], wherein the proportion of the primary monoamine having a number average molecular weight of 300 or less (b2) is 35 mass% to 65 mass% based on the total amount of the component (b1) to (b3).

[8] The paint composition according to any one of [1] to [7], wherein the binder component (A) contains a hydroxy-containing

resin (A1) and a crosslinking agent (A2).

[9] The paint composition according to [8], wherein the hydroxy-containing resin (A1) is a hydroxy-containing acrylic resin (A1-1).

[10] The paint composition according to [8] or [9], wherein the hydroxy-containing resin (A1) contains a secondary hydroxy-containing acrylic resin (A1-1a).

[11] The paint composition according to any one of [8] to [10], wherein the hydroxy-containing resin (A1) contains a hydroxy- and alkoxysilyl-containing acrylic resin (A1-1b).

[12] The paint composition according to any one of [8] to [11], wherein the hydroxy-containing resin (A1) contains a secondary hydroxy- and alkoxysilyl-containing acrylic resin (B1-1c).

[0277]

[13] The paint composition according to any one of [8] to [12], wherein the crosslinking agent (A2) contains one, or two or more polyisocyanate compounds, and the content of the polyisocyanate compound is 5 to 60 parts by mass, per 100 parts by mass of the solids content of the binder component.

[14] The paint composition according to any one of [8] to [12], wherein the crosslinking agent (A2) contains a blocked polyisocyanate compound, and the content of the blocked polyisocyanate compound is 5 to 60 parts by mass, per 100 parts by mass of the total solids content of the binder component.

[15] The paint composition according to any one of [8] to [12], wherein the crosslinking agent (A2) contains an amino resin, and the content of the amino resin is 0.5 to 40 parts by mass, per 100 parts by mass of the total solids content of the binder component.

[16] The paint composition according to any one of [1] to [15], wherein the content of the first rheology control agent (B) is within a range of 0.1 to 2 parts by mass, per 100 parts by mass of the solids content of the binder component (A), and
the content of the second rheology control agent (C) is within a range of 0.1 to 2 parts by mass, per 100 parts by mass of the

solids content of the binder component (A).

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

[Claim 1]

A paint composition comprising

(A) a binder component,

(B) a first rheology control agent, and

(C) a second rheology control agent,

wherein

the first rheology control agent (B) contains a reaction product of (b1) a polyisocyanate compound, (b2) a primary monoamine having a number average molecular weight of 300 or less, and (b3) a polyether amine having a number average molecular weight of more than 300 and less than 6000,

the proportion of the polyether amine having a number average molecular weight of more than 300 and less than 6000 (b3) is 0.5 mass% or more and less than 10 mass% based on the total amount of the components (b1) to (b3),

the second rheology control agent (C) contains a reaction product of (c1) a polyisocyanate compound, (c2) a primary monoamine having a number average molecular weight of 300 or less, and (c3) a polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000, and

the proportion of the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) is more than 15 mass% and 30 mass% or less based on the total amount of the components (c1) to (c3).

[Claim 2]

The paint composition according to claim 1, wherein the polyether amine having two or more amino groups and having a number average molecular weight of 1000 or more and less than 6000 (c3) has three or more amino groups.

[Claim 3]

The paint composition according to claim 1 or 2, wherein the binder component (A) contains a hydroxy-containing resin (AU and a crosslinking agent (A2).

[Claim 4]

The paint composition according to any one of claims 1 to 3, wherein the content of the first rheology control agent (B) is within a range of 0.1 to 2 parts by mass, per 100 parts by mass of the solids content of the binder component (A), and

the content of the second rheology control agent (C) is within a range of 0.1 to 2 parts by mass, per 100 parts by mass of the solids content of the binder component (A).