

DESCRIPTION

TITLE OF INVENTION: COATING COMPOSITION AND COATING FILM

TECHNICAL FIELD

[0001]

The present disclosure relates to a coating composition and a coating film, and particularly relates to a coating composition and a coating film for a detection target of sensing using near-infrared light.

BACKGROUND ART

[0002]

One of remote sensing technologies using light is laser imaging detection and ranging (LiDAR) in which a target is irradiated with near-infrared light, visible light, and/or ultraviolet light, the light reflected and/or scattered by the target is measured, and a distance and a direction from the irradiation position to the target are thereby detected. Such a LiDAR technology is, for example, a technology essential for an advanced autonomous driving system that detects an obstacle and automatically applies a brake in a vehicle, or measures the speed and the inter-vehicle distance of a surrounding vehicle to control the speed and the inter-vehicle distance of the host vehicle. In order to properly operate the advanced autonomous driving system, it is necessary to improve detection accuracy of LiDAR.

In addition, LiDAR often uses near-infrared radiation as irradiation light.

[0003]

As a resin composition for the LiDAR technology, there was proposed a resin composition including a transparent resin and a light absorber, wherein a cured body obtained by molding the resin composition into a thickness of 1 mm has an average light transmittance of 40% or less in a wavelength range of 380 nm to 700, and has a

light transmittance of 70% or more at a wavelength of the laser light used in LiDAR (Patent Literature 1).

CITATIONS LIST

PATENT LITERATURE

[0004]

Patent Literature 1: JP-A-2017-167484

SUMMARY OF INVENTION

TECHNICAL PROBLEMS

[0005]

Most of the development of the LiDAR technology are mainly performed on an aspect regarding hardware such as a sensor or a light source. Patent Literature 1 also relates to an invention of a material used for a wavelength selection filter disposed in front of an element that receives reflection of laser light. In contrast to this, the present inventors have focused on enhancing the intensity of signals (reflected light and scattered light) emitted from a detection target, which is not a side detecting signals (reflected light and scattered light), namely a “passive side”, but a side emitting signals, namely an “active side”, which is conceptually opposing the passive side. Then, the present inventors have conceived a challenge of enhancing the reflection and/or scattering intensity of near-infrared radiation on a detection target in order to enhance the detection accuracy.

[0006]

Furthermore, when the reflection intensity and/or scattering intensity of near-infrared radiation is high, the reflection intensity and/or scattering intensity tends to be high also in a visible light region, which is a wavelength region close to that of near-infrared radiation, and as a result, the lightness of a coated object also tends to be high.

On the other hand, examples of the detection target in the LiDAR technology include a dark color (also referred to as low lightness color) road structure represented by a pavement, a sidewalk, etc. Therefore, as a coating material for a detection target in the LiDAR technology, a coating material having low lightness with respect to light in a visible light region and capable of reflecting and/or scattering with high intensity with respect to light in a near-infrared region is required.

[0007]

A challenge of the present disclosure is to provide a coating composition and a coating film capable of enhancing the near-infrared detection accuracy in the LiDAR technology. Furthermore, a challenge of the present disclosure is to provide a coating composition and a coating film capable of enhancing the near-infrared detection accuracy in the LiDAR technology while having low lightness.

SOLUTIONS TO PROBLEMS

[0008]

The present disclosure comprise the following.

<1> A coating composition for a detection target of sensing using near-infrared light, comprising: a coating film-forming resin (A); and a coloring pigment (B),

wherein the coloring pigment (B) comprises at least one pigment selected from the group consisting of a white pigment having a near-infrared reflectance of 60% or more, a chromatic pigment having a near-infrared reflectance of 50% or more, and a black pigment having a near-infrared reflectance of 30% or more, and

wherein a near-infrared reflectance is defined as a reflectance in a wavelength region of 800 to 2,500 nm.

<2> The coating composition for a detection target of sensing using near-infrared light according to <1>, wherein the chromatic pigment comprises at least one pigment

selected from the group consisting of a red pigment, a yellow pigment, and a blue pigment.

<3> The coating composition for a detection target of sensing using near-infrared light according to <1> or <2>, wherein the red pigment and the yellow pigment each comprise an organic pigment and/or an inorganic pigment.

<4> The coating composition for a detection target of sensing using near-infrared light according to any one of claims <1> to <3>,

wherein the coloring pigment (B) comprises at least one pigment selected from the group consisting of:

a white pigment having a spectral reflectance of 70% or more at a wavelength of 905 nm and/or 1,550 nm;

an organic red pigment having a spectral reflectance of 50% or more at the above-specified wavelength;

an inorganic red pigment having a spectral reflectance of 20% or more at the above-specified wavelength;

an organic yellow pigment having a spectral reflectance of 60% or more at the above-specified wavelength;

an inorganic yellow pigment having a spectral reflectance of 20% or more at the above-specified wavelength;

a blue pigment having a spectral reflectance of 40% or more at the above-specified wavelength;

an organic black pigment having a spectral reflectance of 30% or more at the above-specified wavelength; and

an inorganic black pigment having a spectral reflectance of 15% or more at the above-specified wavelength.

<5> The coating composition for a detection target of sensing using near-infrared light according to any one of <1> to <4>, wherein a coating film to be formed has a lightness of 80 or less.

<6> A coating film for a detection target of sensing using near-infrared light, having a near-infrared reflectance of 15% or more in a wavelength region of 800 to 2,500 nm.

<7> A coating film for a detection target of sensing using near-infrared light, the coating film being formed from the coating composition according to any one of <1> to <5>.

<8> The coating film for a detection target of sensing using near-infrared light according to <7>, having a near-infrared reflectance 15% or more in a wavelength region of 800 to 2,500 nm of.

<9> The coating film for a detection target of sensing using near-infrared light according to any one of <6> to <8>, wherein the coating film has a spectral reflectance of 20% or more at a wavelength of 905 nm and/or 1,550 nm.

<10> A detection target having a coating film formed using the coating composition for a detection target of sensing according to any one of <1> to <5>.

<11> A sensing method for measuring a distance between a vehicle and a detection target, wherein the method comprises: emitting near-infrared radiation having a specific wavelength from a traveling vehicle; reflecting the near-infrared radiation on the detection target; detecting light reflected on the detection target; and calculating the distance from the vehicle to the detection target on a basis of a time required for reflection,

wherein the coated object is obtained by applying the coating composition according to any one of <1> to <5>.

<12> A sensing method for measuring a distance between a vehicle and a detection target, wherein the method comprises: emitting near-infrared radiation having a specific wavelength from a traveling vehicle; reflecting the near-infrared radiation on the detection target; detecting light reflected on the detection target; and calculating the distance from the vehicle to the detection target on a basis of a difference in frequency between emitted light and reflected light,

wherein the coated object is obtained by applying the coating composition according to any one of <1> to <5>.

ADVANTAGEOUS EFFECTS OF INVENTION

[0009]

The coating composition and the coating film of the present disclosure can enhance the near-infrared detection accuracy in the LiDAR technology, and preferably can enhance the near-infrared detection accuracy in the LiDAR technology while having low lightness.

DESCRIPTION OF EMBODIMENTS

[0010]

The coating composition is for a detection target of sensing using near-infrared light, and comprises a coating film-forming resin (A) and a pigment (B). Specifically, the sensing may be a remote sensing technology, and may be a technology of irradiating a detection target with near-infrared radiation, detecting reflected light and/or scattered light from an irradiated position, and then specifying a distance and a direction from a near-infrared radiation emission position to the irradiated position.

[0011]

The wavelength of the near-infrared light to be used for the sensing is preferably 800 nm or more, more preferably 900 nm or more, and preferably 2,500 nm

or less, more preferably 2,000 nm or less, and further preferably 1,600 nm or less. The shorter the wavelength of the near-infrared light is, the higher the straightness the light becomes, whereas the longer the wavelength of the near-infrared light is, the easier the elimination of the influence of sunlight becomes. Currently, wavelengths employed in sensing are mainly 905 nm and/or 1,550 nm.

[0012]

Hereinafter, a coating composition for a detection target of sensing using near-infrared light may be simply referred to as a “coating composition”.

[0013]

[Coating film-forming resin (A)]

The coating film-forming resin (A) is a resin capable of forming a coating film, and a resin commonly used in the field of coating material can be used. Examples of the coating film-forming resin (A) comprise thermosetting resins, normal temperature curable resins, or photocurable resins such as acrylic resin, polyester resin, polyurethane resin, alkyd resin, polyether resin, fluororesin, epoxy resin, silicone resin, or urea resin. The coating film-forming resin (A) may be the one that forms a coating film by the coating film-forming resin (A) itself, or may be the one that forms a coating film by the action of a crosslinking agent (C) described later. As the coating film-forming resin (A), one resin may be used, or two or more of them may be used in combination.

[0014]

The acrylic resin represents a polymer having a unit derived from a monomer having a (meth)acryloyl group, and can be prepared by polymerizing a monomer mixture including the monomer having a (meth)acryloyl group. The monomer mixture may further comprise a monomer having an ethylenically unsaturated bond other than

the monomer having a (meth)acryloyl group. In the present description, (meth)acrylic acid shall mean acrylic acid and methacrylic acid.

[0015]

Examples of the monomer having a (meth)acryloyl group comprise (meth)acrylic acid; (meth)acrylic acid alkyl esters having a linear or branched alkyl group having 1 to 20 carbon atoms; (meth)acrylic monomers having a hydroxy group such as hydroxymethyl (meth)acrylate, hydroxyethyl (meth)acrylate, hydroxypropyl (meth)acrylate, hydroxybutyl (meth)acrylate, and N-methylol(meth)acrylamide; lactone adducts of the (meth)acrylic monomers having a hydroxy group; and (meth)acrylonitrile.

[0016]

Examples of the monomer having an ethylenically unsaturated group comprise monomers having a carboxy group such as crotonic acid, itaconic acid, and fumaric acid; anhydrides of the monomers having a carboxy group; and vinyl monomers such as styrene, as well as the monomers having a (meth)acryloyl group.

[0017]

The polyester resin represents a polymer having a plurality of ester linkages in a main chain, and can be obtained as a reaction product of a polyol and a polycarboxylic acid; an addition polymerization product of a cyclic ester; a reaction product of a reaction product of the polyol and the polycarboxylic acid with a cyclic ester; or the like.

[0018]

The polyol is a compound having two or more hydroxy groups in one molecule, and examples thereof comprise aliphatic polyols such as ethylene glycol, diethylene glycol, polyethylene glycol, propylene glycol, dipropylene glycol,

polypropylene glycol, 1,2-butanediol, 1,3-butanediol, 2,3-butanediol, 1,4-butanediol, 1,4-pentanediol, neopentyl glycol, and 1,5-hexanediol; alicyclic polyols such as hydrogenated bisphenol A and 1,4-cyclohexanedimethanol; aromatic polyols such as bisphenol A and hydroxyalkylated bisphenol A; tri- or more functional polyols such as glycerin, annitol, trimethyloethane, trimethylolpropane, trimethylolbutane, hexanetriol, pentaerythritol, and dipentaerythritol; tris(hydroxyethyl)isocyanate; and N,N-bis(2-hydroxyethyl)dimethylhydantoin.

[0019]

The number of the hydroxy groups in one molecule of the polyol is preferably 2 or more, may be 3 or more, and is preferably 6 or less, and more preferably 4 or less.

[0020]

As the polyol, one polyol may be used, or two or more of them may be used in combination.

[0021]

The polycarboxylic acid represents a compound having two or more carboxy groups in one molecule. Examples of the polycarboxylic acid comprise aromatic polycarboxylic acids such as phthalic acid, isophthalic acid, terephthalic acid, trimellitic acid, and pyromellitic acid; alicyclic polycarboxylic acids such as tetrahydrophthalic acid, hexahydrophthalic acid, methyltetrahydrophthalic acid, cyclohexane-1,4-dicarboxylic acid, 5-norbornene-2,3-dicarboxylic acid, and methyl-5-norbornene-2,3-dicarboxylic acid; aliphatic polycarboxylic acids such as maleic acid, fumaric acid, itaconic acid, adipic acid, azelaic acid, sebacic acid, succinic acid, and dodecenylsuccinic acid; hydroxy acids such as lactic acid; and anhydrides of the aromatic polycarboxylic acids, the alicyclic polycarboxylic acids, and the aliphatic

polycarboxylic acids. As the polycarboxylic acid, one polycarboxylic acid may be used, or two or more of them may be used in combination.

[0022]

Examples of the cyclic ester comprise ϵ -caprolactone.

[0023]

The polyester resin comprises a modified product of the polyester resin described above as well. The modification of the resin can be performed by reacting a modifier with the terminal of the main chain constituting the resin. Examples of the modifier comprise compounds having a reactive group such as an isocyanate group, a hydroxy group, or a carboxy group, and a compound having a silicone skeleton. Examples of the modified products of polyester resin comprise urethane-modified polyester resins, epoxy-modified polyester resins, acrylic-modified polyester resins, and silicone-modified polyester resins.

[0024]

Examples of the urethane resin comprise a reaction product of a polyol with a polyisocyanate; and a reaction product of that reaction product with a chain extender to be used as necessary.

[0025]

The polyol represents a compound having two or more hydroxy groups in one molecule. Examples of the polyol comprise aliphatic polyols such as ethylene glycol, diethylene glycol, polyethylene glycol, propylene glycol, dipropylene glycol, polypropylene glycol, 1,2-butanediol, 1,3-butanediol, 2,3-butanediol, 1,4-butanediol, 1,4-pentanediol, neopentyl glycol, 1,5-hexanediol, and 1,6-hexanediol; alicyclic polyols such as hydrogenated bisphenol A and 1,4-cyclohexanedimethanol; aromatic polyols such as bisphenol A, hydroxyalkylated bisphenol A (especially, bisphenol

hydroxypropyl ether); tri- or more functional polyols such as glycerin, annitol, trimethylolethane, trimethylolpropane, trimethylolbutane, hexanetriol, pentaerythritol, and dipentaerythritol; and high molecular weight polyols (for example, polyols having a weight average molecular weight of 800 or more) such as polyether polyol, acrylic polyol, polyurethane polyol, polyester polyol, and polyester amide polyol. As the polyol, one polyol may be used, or two or more of them may be used in combination.

[0026]

The number of the hydroxy groups in the polyol is 2 or more, may be 3 or more, and is preferably 6 or less, and more preferably 4 or less.

[0027]

The polyisocyanate represents a compound having two or more isocyanate groups in one molecule. Examples of the polyisocyanate comprise aliphatic polyisocyanates such as hexamethylene diisocyanate; alicyclic polyisocyanates such as dicyclohexylmethane diisocyanate, isophorone diisocyanate, and hydrogenated xylylene diisocyanate; and aromatic polyisocyanates such as tolylene diisocyanate, xylylene diisocyanate, diphenylmethane diisocyanate, naphthylene diisocyanate, and 3,3'-dimethyl-4,4'-biphenylene diisocyanate. As the polyisocyanate, one polyisocyanate may be used, or two or more of them may be used in combination.

[0028]

The chain extender means a compound having one or more active hydrogen atoms in one molecule, and water or an amine compound can be used. Examples of the amine compound comprise aliphatic polyamines such as ethylenediamine, propylenediamine, hexamethylenediamine, diethylenetriamine, dipropylenetriamine, triethylenetetramine, and tetraethylenepentamine; aromatic polyamines such as tolylenediamine, xylylenediamine, and diaminodiphenylmethane; alicyclic polyamines

such as diaminocyclohexylmethane, piperazine, 2,5-dimethylpiperazine, and isophoronediamine; hydrazine compounds such as hydrazine, succinic dihydrazide, adipic dihydrazide, and phthalic dihydrazide; and alkanolamines such as hydroxyethyldiethylenetriamine, 2-[(2-aminoethyl)amino]ethanol, and 3-aminopropanediol.

[0029]

In one embodiment, as the urethane resin, ester-based urethane resins, ether-based urethane resins, and carbonate-based urethane resins can be used.

[0030]

The epoxy resin may be, for example, an epoxy resin having two or more epoxy groups in one molecule. Examples thereof specifically comprise glycidyl ester resins; glycidyl ether-type resins such as condensates of bisphenol A and epichlorohydrin and condensates of bisphenol F and epichlorohydrin; alicyclic epoxy resins, linear aliphatic epoxy resins, bromine-containing epoxy resins, phenol novolac-type epoxy resins, and cresol novolac-type epoxy resins.

[0031]

The coating film-forming resin (A) may have a hydrophilic group such as an anionic group, a cationic group, or a nonionic group. Examples of the anionic group comprise a carboxy group and a sulfonic acid group, and examples of the cationic group comprise an amino group and a quaternary ammonium group. Examples of the nonionic group comprise polyoxyalkylene units. The hydrophilic group can be introduced by, for example, using a compound having a hydrophilic group as a starting material of the coating film-forming resin (A).

[0032]

When the coating film-forming resin (A) has an anionic group, the coating composition may comprise a basic compound capable of neutralizing the anionic group, and when the coating film-forming resin (A) has a cationic group, the coating composition may comprise an acidic compound capable of neutralizing the cationic group.

[0033]

When the coating film-forming resin (A) has an anionic group, the acid value of the coating film-forming resin (A) is preferably 5 mg KOH/g or more, and is preferably 50 mg KOH/g or less, and more preferably 30 mg KOH/g or less.

[0034]

When the coating film-forming resin (A) has a cationic group, the amine value of the coating film-forming resin (A) is preferably 5 mg KOH/g or more, and is preferably 50 mg KOH/g or less, and more preferably 30 mg KOH/g or less.

[0035]

The coating film-forming resin (A) may have a hydroxy group. When the coating film-forming resin (A) has a hydroxy group, the hydroxyl value of the coating film-forming resin (A) is 5 mg KOH/g or more, preferably 7 mg KOH/g or more, and more preferably 10 mg KOH/g or more, and is 35 mg KOH/g or less, preferably 30 mg KOH/g or less, and more preferably 25 mg KOH/g or less.

[0036]

The acid value and the hydroxyl value are both based on a solid content, and can be measured in accordance with JIS K 0070: 1999. The amine value is based on a solid content, and can be measured in accordance with JIS K 7237.

[0037]

The coating film-forming resin (A) may be a resin that can be dissolved in an organic solvent described later, or may be an aqueous resin. Examples of the aqueous resin comprise water-soluble resins that can be dissolved in an aqueous medium; and water-dispersible resins that can be dispersed in an aqueous medium, such as a colloidal dispersion type or an emulsion type (emulsion polymerization type, forced emulsion type).

[0038]

The weight average molecular weight of the coating film-forming resin (A) may be, for example, 2,000 or more, 10,000 or more, or 50,000 or more, and may be 10,000,000 or less, 2,000,000 or less, or 500,000 or less.

For the emulsion type water-dispersible resin, the weight average molecular weight of the coating film-forming resin (A) may be, for example, 50,000 or more, 100,000 or more, or 150,000 or more. The weight average molecular weight may be 10,000,000 or less, 2,000,000 or less, or 500,000 or less.

For the resin that can be dissolved in an aqueous medium or an organic solvent, for example, the weight average molecular weight may be 2,000 or more, 10,000 or more, or 50,000 or more, and may be 100,000 or less, or 80,000 or less.

In the present description, the weight average molecular weight is a polystyrene-equivalent value calculated from a value measured by gel permeation chromatography.

[0039]

The content of the coating film-forming resin (A) in the solid component of the coating composition is preferably 50% by mass or more, more preferably 60% by mass or more, and still more preferably 65% by mass or more, and is preferably 90% by mass

or less, more preferably 85% by mass or less, and still more preferably 75% by mass or less.

[0040]

In the present description, the solid component of the coating composition shall mean a portion obtained by excluding a solvent (D) described later from all components of the coating composition.

[0041]

In the coating composition, a thermoplastic resin may also be used in addition to the coating film-forming resin (A) as long as the physical properties of the coating film to be formed are not affected. Examples of the thermoplastic resin comprise chlorinated olefin-based resins such as chlorinated polyethylene and chlorinated polypropylene; homopolymers or copolymers containing vinyl chloride, vinyl acetate, vinylidene chloride, or others as monomer components; cellulose-based resins; acetal resins; alkyd resins; chlorinated rubber-based resins; modified polypropylene resins (acid anhydride-modified polypropylene resins, etc.); and fluororesins (for example, vinylidene fluoride resin, vinyl fluoride resin, copolymers of fluorinated olefin and vinyl ether, and copolymers of fluorinated olefin and vinyl ester). As the thermoplastic resin, one thermoplastic resin may be used, or two or more of them may be used in combination. Use of a thermoplastic resin in combination makes it easy to adjust the physical properties of the coating film to be formed according to the purpose.

[0042]

[Organic pigment (B)]

The coloring pigment (B) is a pigment having a color such as a chromatic color or an achromatic color, and comprise a pigment (B1) capable of reflecting near-infrared radiation. The near-infrared reflectance of the pigment (B1) is preferably 10% or

more, more preferably 15% or more, still more preferably 20% or more, and it is also acceptable that the near-infrared reflectance is 100% or less, 90% or less, or 80% or less. By containing the pigment (B1), when near-infrared radiation is applied, the applied light is reflected and/or scattered with high intensity, and this can contribute to improvement of detection accuracy in the LiDAR technology.

[0043]

In the present description, the near-infrared reflectance means an arithmetic average value of spectral reflectance measured in accordance with JIS K 5602: 2008 in a wavelength region of 800 to 2,500 nm. The spectral reflectance can be measured using a spectrophotometer.

[0044]

In the present description, the near-infrared reflectance of a pigment can be measured as the reflectance of a formed coating film containing the pigment. Specifically, a pigment, a resin, and a solvent described in Measurement Example 1 of near-infrared reflectance and spectral reflectance of a pigment to be described later are mixed such that a pigment mass concentration (also referred to as PWC) represented by the following formula is 3 to 50% by mass. The mixture is dispersed using a disperser at a rotation speed of 1,800 rpm for 60 minutes to form a dispersion. Thereafter, the dispersion is applied to a black-and-white hiding ratio test paper (manufactured by Nippon Testpanel Co., Ltd.) as a base by using an 8 mil doctor blade such that a thickness after drying is about 50 μm , and then dried at 60°C for 20 minutes to form a dry coating film. In accordance with JIS K 5602: 2008, the spectral reflectance of a part of the dry coating film where the base is white is measured in a wavelength region of 800 to 2,500 nm using a spectrophotometer, and the arithmetic average value thereof is taken as the near-infrared reflectance of the pigment. In addition, spectral

reflectance at wavelengths of 905 nm and 1,550 nm described later can also be measured in accordance with the above-described method for measuring spectral reflectance. As the spectrophotometer, for example, a spectrophotometer (Shimadzu Corporation, SHIMADZU-UV 3600 or the like) can be used for the measurement.

Pigment mass concentration (PWC: % by mass) = (solid content of pigment)/(solid content of pigment + solid content of resin) × 100

[0045]

In the present specification, the solid content of the resin can be determined by measuring the heated residue (the mass of the residue after heating at 105°C for 60 minutes) in accordance with JIS K 5601-1-2 (2008).

[0046]

In the measurement of the near-infrared reflectance and the spectral reflectance, the pigment mass concentration of each of the pigments is set to be equal to or higher than a concentration at which white and black of the base are not seen through when a dry coating film is formed on the black-and-white hiding ratio test paper. In the present description, the pigment mass concentration of each of the pigments is 25% by mass for the organic red pigment, 30% by mass for the inorganic red pigment, 25% by mass for the organic yellow pigment, 30% by mass for the inorganic yellow pigment, 20% by mass for the blue pigment, 45% by mass for the white pigment, 3% by mass for the organic black pigment, and 50% by mass for the inorganic black pigment.

[0047]

The pigment (B1) preferably comprises a pigment selected from the group consisting of a chromatic pigment and an achromatic pigment. The chromatic pigment comprises any pigment having a color with a chroma exceeding 0, and examples thereof comprise a red pigment, a green pigment, a blue pigment, and a yellow pigment. The

chromatic pigment preferably comprises one or more pigments selected from the group consisting of a red pigment, a blue pigment, and a yellow pigment, and more preferably comprises one or more pigments selected from the group consisting of a red pigment, a blue pigment, and a yellow pigment.

[0048]

As the pigment (B1), an organic pigment and/or an inorganic pigment may be used. The organic pigment tends to have high chroma or high near-infrared reflectance, and the inorganic pigment tends to have high weather resistance.

The content of the organic pigment in the pigment (B1) may be 0% by mass or more, 0.5% by mass or more, or 3% by mass or more. The content may be 100% by mass or less, 70% by mass or less, 20% by mass or less, 10% by mass or less, or 8% by mass or less.

The content of the inorganic pigment in the pigment (B1) may be 0% by mass or more, 5% by mass or more, or 10% by mass or more. The content may be 100% by mass or less, 99% by mass or less, 50% by mass or less, 40% by mass or less, or 20% by mass or less.

[0049]

The near-infrared reflectance of the red pigment as the pigment (B1) is, for example, preferably 40% or more, more preferably 45% or more, still more preferably 50% or more, and further preferably 55% or more, and for example, it is also acceptable that the near-infrared reflectance is 80% or less, or 70% or less.

The spectral reflectance of the red pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 20% or more, more preferably 25% or more, still more preferably 30% or more, and further preferably 35% or more, and for example, it is also acceptable that the spectral reflectance is 90% or less, or 85% or less.

[0050]

As the red pigment, an organic pigment and/or an inorganic pigment may be used. The content of the organic pigment in the red pigment may be 0% by mass, 1% by mass or more, or 20% by mass or more, and may be 50% by mass or less, and the upper limit is 100% by mass.

[0051]

The near-infrared reflectance of the organic red pigment is preferably 40% or more, more preferably 45% or more, still more preferably 50% or more, and further preferably 55% or more, and for example, it is also acceptable that the near-infrared reflectance is 80% or less, or 70% or less.

[0052]

The spectral reflectance of the organic red pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 40% or more, more preferably 50% or more, still more preferably 55% or more, and further preferably 60% or more, and for example, it is also acceptable that the spectral reflectance is 90% or less, or 85% or less.

[0053]

The near-infrared reflectance of the inorganic red pigment is preferably 40% or more, more preferably 45% or more, and for example, it is also acceptable that the near-infrared reflectance is 80% or less, or 70% or less.

[0054]

The spectral reflectance of the inorganic red pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 20% or more, more preferably 30% or more, for example, 90% or less, and further 85% or less.

[0055]

Examples of the red pigment as the pigment (B1) comprise Fastogen Super Magenta RH, Fastogen Red 7100Y, Fastogen Super Red 500RG, Fastogen Super Red ATY, Fastogen Super Blue Violet RVS, Rubicron Red 400RG, Rubicron Red 500RG (all manufactured by DIC Corporation), and CINILEX DPP RED SR1C (manufactured by CINIC chemicals) as organic red pigments, and Toda Color 120ED (manufactured by Toda Kogyo Corp.) and BAYFERROX 130M (manufactured by LANXESS) as inorganic red pigments.

[0056]

The near-infrared reflectance of the blue pigment as the pigment (B1) is preferably 40% or more, and more preferably 45% or more, and for example, it is also acceptable that the near-infrared reflectance is 80% or less, or 70% or less.

[0057]

The spectral reflectance of the blue pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 30% or more, more preferably 35% or more, and for example, it is also acceptable that the spectral reflectance is 90% or less, or 85% or less.

[0058]

Examples of the blue pigment comprise Daipyroxide Color Blue 9453 (manufactured by Dainichiseika Color & Chemicals Mfg. Co., Ltd.), Fastogen Blue 9453, Fastogen Blue RS, Fastogen Blue 5380, and Fastogen Super Blue 6070 S (all manufactured by DIC Corporation), Cyanine Blue 5240KB, Cyanine Blue 5050 (all manufactured by Dainichiseika Color & Chemicals Mfg. Co., Ltd.), HELIOGEN BLUE L7460 (manufactured by BASF), Daipyroxide Color Green 9310 (manufactured by Dainichiseika Color & Chemicals Mfg. Co., Ltd.), Fastogen Green 2YK, Fastogen Green MY (all manufactured by DIC Corporation), and LIONOL Green 6YKP-N (manufactured by Toyocolor Co., Ltd.).

[0059]

The near-infrared reflectance of the yellow pigment is preferably 40% or more, more preferably 45% or more, still more preferably 50% or more, and further preferably 55% or more, and for example, it is also acceptable that the near-infrared reflectance is 90% or less, or 85% or less.

[0060]

The spectral reflectance of the yellow pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 15% or more, more preferably 20% or more, still more preferably 25% or more, and further preferably 30% or more, and for example, it is also acceptable that the spectral reflectance is 95% or less, or 90% or less.

[0061]

As the yellow pigment, an organic pigment and/or an inorganic pigment may be used. The content of the organic pigment in the yellow pigment may be 0% by mass, 1% by mass or more, or 10% by mass or more. The content may be 50% by mass or less, and the upper limit is 100% by mass.

[0062]

The near-infrared reflectance of the organic yellow pigment is preferably 40% or more, more preferably 45% or more, still more preferably 50% or more, and further preferably 55% or more, and for example, it is also acceptable that the near-infrared reflectance is 90% or less, or 85% or less.

[0063]

The spectral reflectance of the organic yellow pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 40% or more, more preferably 45% or more, still more preferably 50% or more, and further preferably 55% or more, and for example, it is also acceptable that the spectral reflectance is 95% or less, or 90% or less.

[0064]

The near-infrared reflectance of the inorganic yellow pigment is preferably 40% or more, more preferably 45% or more, still more preferably 50% or more, and further preferably 55% or more, and for example, it is also acceptable that the near-infrared reflectance is 90% or less, or 85% or less.

[0065]

The spectral reflectance of the inorganic yellow pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 20% or more, and more preferably 25% or more, and for example, it is also acceptable that the spectral reflectance is 90% or less, or 85% or less.

[0066]

Examples of the yellow pigment comprise Symuler Fast Yellow 4192 (manufactured by DIC Corporation) and HOSTAPERM YELLOW H3G (manufactured by Clariant Japan K.K.) as organic yellow pigments. Examples of the inorganic yellow pigment comprise Sicopal Yellow L-1110 and Sicopal Yellow L-1100 (both manufactured by BASF), and TAROX iron oxide YM1100 (manufactured by Titan Kogyo, Ltd.).

[0067]

The chromatic pigment as the pigment (B1) preferably comprises a red pigment, a blue pigment, and a yellow pigment. Examples thereof comprise a mixture of Symuler Fast Yellow 4192 (manufactured by DIC Corporation) as a yellow pigment, Fastogen Red 7100Y (manufactured by DIC Corporation) as a red pigment, and LIONOL Blue FG7980 (manufactured by Toyocolor Co., Ltd.) as a blue pigment.

[0068]

The total content of the red pigment, the blue pigment, and the yellow pigment in the chromatic pigment is, for example, 20% by mass or more, preferably 30% by mass or more, and the upper limit is 100% by mass.

[0069]

The content of the chromatic pigment in the pigment (B1) may be, for example, 0% by mass or more, 1% by mass or more, or 5% by mass or more. For example, the content may be 100% by mass or less, 70% by mass or less, 50% by mass or less, 25% by mass or less, 20% by mass or less, or 18% by mass or less.

[0070]

The achromatic pigment comprises any pigment having a chroma of 0. Examples of the achromatic pigment comprise a white pigment, a gray pigment, and a black pigment, and the achromatic pigment comprises a white pigment and a black pigment.

[0071]

The near-infrared reflectance of the white pigment as the pigment (B1) is preferably 60% or more, more preferably 65% or more, still more preferably 70% or more, and further preferably 75% by mass or more, and for example, it is also acceptable that the near-infrared reflectance is 99% or less, or 90% or less.

[0072]

Examples of the white pigment comprise TIPAQUE CR-97 and TIPAQUE CR-95 (both manufactured by Ishihara Sangyo Kaisha, Ltd.), which are titanium oxide, and TI-PURE R-902 (manufactured by DuPont de Nemours, Inc.).

[0073]

The spectral reflectance of the white pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 60% or more, more preferably 65% or more, still more

preferably 70% or more, and further preferably 75% by mass or more, and for example, it is also acceptable that the spectral reflectance is 99% or less, or 90% or less.

[0074]

The content of the white pigment in the pigment (B1) may be, for example, 0% by mass or more, 1% by mass or more, or 3% by mass or more. The content is 100% by mass or less, and may be 99% by mass or less, or 90% by mass or less, and for example, may be 60% by mass or less, 55% by mass or less, or 50% by mass or less.

[0075]

The near-infrared reflectance of the black pigment as the pigment (B1) is preferably 5% or more, more preferably 8% or more, still more preferably 10% or more, and further preferably 15% or more, and for example, it is also acceptable that the near-infrared reflectance is 90% or less, or 85% or less.

[0076]

The spectral reflectance of the black pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 5% or more, more preferably 8% or more, still more preferably 10% or more, and further preferably 15% or more, and for example, it is also acceptable that the spectral reflectance is 90% or less, or 85% or less.

[0077]

As the black pigment, an organic pigment and/or an inorganic pigment may be used. The content of the organic pigment in the black pigment may be 0% by mass, 1% by mass or more, 20% by mass or more, or 50% by mass or less, and the upper limit is 100% by mass.

[0078]

The near-infrared reflectance of the organic black pigment is preferably 20% or more, more preferably 30% or more, still more preferably 35% or more, and further

preferably 40% or more, and for example, it is also acceptable that the near-infrared reflectance is 80% or less, or 70% or less.

[0079]

The spectral reflectance of the organic black pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 40% or more, more preferably 50% or more, still more preferably 55% or more, and further preferably 60% or more, and for example, it is also acceptable that the spectral reflectance is 90% or less, or 85% or less.

[0080]

The near-infrared reflectance of the inorganic black pigment is preferably 30% or more, and more preferably 40% or more, and for example, it is also acceptable that the near-infrared reflectance is 80% or less, or 70% or less.

[0081]

The spectral reflectance of the inorganic black pigment at a wavelength of 905 nm and/or 1,550 nm is preferably 5% or more, and more preferably 10% or more, for example, it is also acceptable that the spectral reflectance is 85% or less, or 80% or less.

[0082]

Examples of the black pigment comprise Daipyroxide Color Black 9590, Daipyroxide Color Brown 9290, Daipyroxide Color Brown 9211 (all manufactured by Dainichiseika Color & Chemicals Mfg. Co., Ltd.), and Black 411 (manufactured by The Shepherd Color Company) as inorganic black pigments, and Black 6350 (manufactured by Asahi Kasei Corporation), and Chromofine Black A-1103 (manufactured by Dainichiseika Color & Chemicals Mfg. Co., Ltd.), Fastogen Super Black MX (manufactured by DIC Corporation), Paliogen Black S 0084, and Paliotol Black L0080 (all manufactured by BASF), and Hostaperm Brown HFR-01 (manufactured by Clariant Japan K.K.) as organic black pigments.

[0083]

The content of the black pigment in the pigment (B1) may be 0% by mass or more, 1% by mass or more, or 5% by mass or more. For example, the content may be 50% by mass or less, 45% by mass or less, or 40% by mass or less.

[0084]

The total content of the white pigment and the black pigment in the achromatic pigment is, for example, 50% by mass or more, and preferably 60% by mass or more, and the upper limit is 100% by mass.

[0085]

The content of the achromatic pigment may be 0 parts by mass or more, 10 parts by mass or more, or 50 parts by mass or more based on 100 parts by mass of the chromatic pigment. For example, the content may be 20,000 parts by mass or less, 10,000 parts by mass or less, 5,000 parts by mass or less, or 2,500 parts by mass or less.

[0086]

As the pigment (B1), one pigment may be used, or two or more of them may be used in combination.

[0087]

In one embodiment, the pigment (B1) comprises at least one pigment selected from the group consisting of a white pigment having a near-infrared reflectance of 60% or more, a chromatic pigment having a near-infrared reflectance of 50% or more, and a black pigment having a near-infrared reflectance of 5% or more. When the pigment (B1) comprises these pigments, it is possible to increase the near-infrared detection accuracy in the LiDAR technology of a coating film to be obtained, and preferably, it is possible to increase the near-infrared detection accuracy in the LiDAR technology while having low lightness.

[0088]

The pigment (B1) preferably comprises at least one pigment selected from the group consisting of a white pigment having a near-infrared reflectance of 60% or more, a blue pigment having a near-infrared reflectance of 50% or more, a red pigment having a near-infrared reflectance of 50% or more, a yellow pigment having a near-infrared reflectance of 50% or more, and a black pigment having a near-infrared reflectance of 30% or more; and more preferably comprises at least one pigment selected from the group consisting of a white pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 70% or more, a blue pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 40% or more, an organic red pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 50% or more, an inorganic red pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 20% or more, an organic yellow pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 60% or more, an inorganic yellow pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 20% or more, an organic black pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 50% or more, and an inorganic black pigment having a spectral reflectance at a wavelength of 905 nm and/or 1,550 nm of 15% or more.

[0089]

The total content of the pigment (B1) in the coloring pigment (B) may be 20% by mass or more, 30% by mass or more, or 50% by mass or more. For example, the total content may be 100% by mass or less, 98% by mass or less, or 95% by mass or less.

[0090]

The coloring pigment (B) may comprise a coloring pigment (b) other than the pigment (B1) as long as neither the near-infrared reflectance nor the spectral reflectance of a coating film obtained from the coating composition is affected. As the coloring pigment (b), any compound categorized as pigment in the Color Index other than the pigment (B1) can be used. Examples of the coloring pigment (b) comprise an organic black pigment, and examples thereof comprise carbon black. The content (pigment mass concentration) of the coloring pigment (b) in the coloring pigment (B) may be 1% by mass or less, 0.5% by mass or less, or 0.1% by mass or less.

[0091]

The content (pigment mass concentration) of the pigment (B) in the total amount of the coating film-forming resin (A) and the pigment (B) is preferably 10% by mass or more, more preferably 15% by mass or more, and still more preferably 20% by mass or more, and is preferably 55% by mass or less, more preferably 50% by mass or less, and still more preferably 45% by mass or less.

[0092]

The lightness (L^* value) of a coating film obtained from the coating composition is preferably 80 or less, and may be, for example, 5 or more. In addition, for example, the lightness may be 70 or less, or may be 15 or more. Use of the coating composition of the present disclosure maintains visibility in the LiDAR technology even when the lightness (L^* value) of a coating film is low. The lightness (L^* value) of a coating film may vary depending on the thickness (film thickness) of the coating film.

[0093]

In the present description, the lightness of a coating film can be measured by the same method as that for the lightness of a coating film containing the pigment

described above. Specifically, the pigment, the resin, and the solvent described above which are also described in Measurement Example 1 of near-infrared reflectance and spectral reflectance of a pigment to be described later are mixed such that a pigment mass concentration is 3 to 50% by mass. The mixture is dispersed using a disperser at a rotation speed of 1,800 rpm for 60 minutes to form a dispersion. Thereafter, the dispersion is applied to a black-and-white hiding ratio test paper (manufactured by Nippon Testpanel Co., Ltd.) as a base such that a thickness after drying is about 100 μm , and then dried at 60°C for 20 minutes to form a dry coating film. For the obtained coating film, the lightness thereof can be determined by measuring, in accordance with JIS K 5600-4-4, 3.2 and JIS K 5600-4-5, the lightness of a part of the obtained dry coating film where the base is white. The lightness can be measured using, for example, a spectrophotometer CM-600d (manufactured by Konica Minolta, Inc.).

[0094]

Where the lightness of a target coating film is L^*_0 , the relationship between the L^*_0 and the ranges of the pigment mass concentrations of the respective pigments is expressed by the following formula. That is, the pigment mass concentration of each of the pigments may be in a range satisfying the following formula. In addition, L^*_0 can take a value in the range described above as the lightness of the coating film.

$$L^*_0 = 0.7 (W) - 0.6 (IR) - 5.5 (OR) + 0.4 (IY) - 3.2 (OY) - 5.7 (OB) - 0.2 (IBL) - 0.3 (OBL) + 48.5 \dots \text{Formula (1)}$$

Here, (W) is a pigment mass concentration (% by mass) of a white pigment, (IR) is a pigment mass concentration (% by mass) of an inorganic red pigment, (OR) is a pigment mass concentration (% by mass) of an organic red pigment, (IY) is a pigment mass concentration (% by mass) of an inorganic yellow pigment, (OY) is a pigment mass concentration (% by mass) of an organic yellow pigment, (OB) is a pigment mass

concentration (% by mass) of a blue pigment, (IBL) is a pigment mass concentration (% by mass) of an inorganic black pigment, and (OBL) is a pigment mass concentration (% by mass) of an organic black pigment.

[0095]

Where the near-infrared reflectance of a target coating film is X_0 (%), the relationship between X_0 (%) and the pigment mass concentrations of the respective pigments is expressed by the following formula. That is, the pigment mass concentration of each of the pigments may be in a range satisfying the following formula. In addition, X_0 (%) can take a value in the range described above as the near-infrared reflectance of the coating film.

$$X_0 = 0.5 (W) - 1.4 (IR) + 0.1 (OR) - 0.6 (IY) - 1.8 (OY) - 3.1 (OB) - 0.2 (IBL) - 13.2 (OBL) + 61.0 \dots \text{Formula (2)}$$

[0096]

When the spectral reflectance of a target coating film at a wavelength of 905 nm is Y_0 (%), the relationship between the spectral reflectance and the pigment mass concentrations of the respective pigments is expressed by the following formula. That is, the pigment mass concentration of each of the pigments may be in a range satisfying the following formula. In addition, Y_0 (%) can take a value in the range described above as the spectral reflectance of the coating film at a wavelength of 905 nm.

$$Y_0 = 0.6 (W) - 2.9 (IR) + 3.5 (OR) - 1.2 (IY) - 0.9 (OY) - 3.0 (OB) - 0.8 (IBL) - 1.2 (OBL) + 68.0 \dots \text{Formula (3)}$$

[0097]

Where the spectral reflectance of a target coating film at a wavelength of 1,550 nm is Z_0 (%), the relationship between Z_0 (%) and the pigment mass concentrations of the respective pigments is expressed by the following formula. That is, the pigment

mass concentration of each of the pigments may be in a range satisfying the following formula. In addition, Z_0 (%) can take a value in the range described above as the spectral reflectance of the coating film at a wavelength of 905 nm.

$$Z_0 = 0.3 (W) - 0.2 (IR) - 2.4 (OR) - 0.2 (IY) - 1.4 (OY) - 2.0 (OB) + 0.1 (IBL) - 8.5 (OBL) + 68.0 \dots \text{Formula (4)}$$

[0098]

The lightness of the coating film may be 80 or less. The combination of the pigment mass concentrations at that time is variously calculated by Formula (1). Among the combinations, combinations of pigment concentrations that make the near-infrared reflectance, the spectral reflectance at a wavelength of 905 nm, and the spectral reflectance at a wavelength of 1,550 nm equal to or more than desired values (for example, 15% or more) can be calculated by Formulas (2) to (4).

[0099]

[Crosslinking agent (C)]

The coating composition may comprise a crosslinking agent (C) in addition to the coating film-forming resin (A) and the pigment (B). The crosslinking agent (C) is a compound capable of forming a crosslinked structure in the coating film-forming resin (A) through forming a chemical bond and/or a physical bond, and examples thereof comprise a compound having two or more groups having an active hydrogen atom, such as a hydroxy group, a carboxy group, or an amino group, in one molecule; or a compound having two or more groups capable of reacting with the group having an active hydrogen atom in one molecule. When the coating film-forming resin (A) has a group having an active hydrogen atom or a group capable of reacting with the group having an active hydrogen atom, a crosslinked structure can be formed in the coating film-forming resin (A) through reacting with the crosslinking agent (C).

[0100]

Examples of the crosslinking agent (C) comprises a polyisocyanate compound, a blocked polyisocyanate compound, an amino resin, a phenol resin, and a polycarboxylic acid. These may be used singly, or two or more of them may be used in combination.

[0101]

The polyisocyanate compound means a compound having two or more isocyanate groups in one molecule. Examples of the polyisocyanate comprise aromatic polyisocyanates such as 2,4-tolylene diisocyanate, 2,6-tolylene diisocyanate, and mixtures thereof, diphenylmethane-4,4'-diisocyanate, diphenylmethane-2,4'-diisocyanate, and mixtures thereof, naphthylene-1,5-diisocyanate, 3,3'-dimethyl-4,4'-biphenylene diisocyanate, and xylylene diisocyanate; alicyclic polyisocyanates such as dicyclohexylmethane diisocyanate, isophorone diisocyanate, and hydrogenated xylylene diisocyanate; and aliphatic polyisocyanates such as hexamethylene diisocyanate.

[0102]

The blocked polyisocyanate compound (hereinafter sometimes referred to as "BI") means a compound in which an isocyanate group of the isocyanate compound is blocked with a blocking agent.

[0103]

The blocking agent may be any compound having an active hydrogen-containing compound, and for example, phenol compounds such as phenol, cresol, and xlenol; lactam compounds such as ϵ -caprolactam, δ -valerolactam, and γ -butyrolactam; aliphatic alcohol compounds such as methanol, ethanol, n-, i- or t-butyl alcohol; glycol ether compounds such as ethylene glycol monoethyl ether, ethylene glycol monobutyl ether, diethylene glycol monoethyl ether, and propylene glycol monomethyl ether;

aromatic alcohol compounds such as benzyl alcohol; oxime compounds such as formamidoxime, acetaldoxime, acetoxime, methyl ethyl ketoxime, diacetyl monoxime, benzophenone oxime, and cyclohexane oxime; active methylene compounds such as dimethyl malonate, diethyl malonate, ethyl acetoacetate, and acetylacetone can be used. By mixing the polyisocyanate compound with the blocking agent, the free isocyanate group of the polyisocyanate compound can be blocked.

[0104]

The amino resin means a resin obtained through addition polymerization of an aldehyde to a compound having an amino group. The amino resin is preferable because it is superior in crosslinking reactivity with the coating film-forming resin (A), and particularly superior in crosslinking reactivity with the coating film-forming resin (A) even in the absence of a catalyst.

[0105]

Examples of the amino resin comprise melamine resin and urea resin, and among them, melamine resin is preferable.

[0106]

The melamine resin means a thermosetting resin synthesized from melamine and an aldehyde. The melamine resin has triazine nuclei and three reactive functional groups ($-NX_1X_2$) per triazine nucleus. Examples of the melamine resin comprise the following four types: a completely alkylated type containing only $-N(CH_2OR)_2$ [R represents an alkyl group having 1 to 8 carbon atoms; the same applies hereinafter] as a reactive functional group; a methylol group type containing $-N(CH_2OR)(CH_2OH)$ as a reactive functional group; an imino group type containing $-N(CH_2OR)(H)$ as a reactive functional group; a methylol/imino group type containing $-N(CH_2OR)(CH_2OH)$ and $-N(CH_2OR)(H)$ or containing $-N(CH_2OH)(H)$ as reactive functional groups. As the

melamine resin, one resin may be used, or two or more resins may be used in combination. The melamine resin and the polyisocyanate compound may be used in combination as the crosslinking agent (C). If necessary, a metal catalyst such as a tin compound or a titanium compound may be used.

[0107]

Examples of the phenol compound comprise glycidyl ether-type resins such as a condensate of bisphenol A and epichlorohydrin and a condensate of bisphenol F and epichlorohydrin; alicyclic epoxy resins, linear aliphatic epoxy resins, bromine-containing epoxy resins, phenol novolac-type epoxy resins, and cresol novolac-type epoxy resins.

[0108]

The polycarboxylic acid means a compound having two or more carboxy groups in one molecule. Examples of the polycarboxylic acid comprise aromatic polycarboxylic acids such as phthalic acid, isophthalic acid, terephthalic acid, trimellitic acid, and pyromellitic acid; alicyclic polycarboxylic acids such as tetrahydrophthalic acid, hexahydrophthalic acid, methyltetrahydrophthalic acid, cyclohexane-1,4-dicarboxylic acid, 5-norbornene-2,3-dicarboxylic acid, and methyl-5-norbornene-2,3-dicarboxylic acid; aliphatic polycarboxylic acids such as maleic acid, fumaric acid, itaconic acid, adipic acid, azelaic acid, sebacic acid, succinic acid, and dodecenylsuccinic acid; hydroxy acids such as lactic acid; and anhydrides of the aromatic polycarboxylic acids, the alicyclic polycarboxylic acids, and the aliphatic polycarboxylic acids.

[0109]

In one embodiment, the crosslinking agent (C) is preferably one or more agents selected from the group consisting of a polyisocyanate compound, a blocked polyisocyanate compound, and an amino resin.

[0110]

The content of the crosslinking agent (C) may be, for example, 3 parts by mass or more, 10 parts by mass or more, 15 parts by mass or more, or 20 parts by mass or more, in 100 parts by mass in total of the coating film-forming resin (A) (100 parts by mass) and the crosslinking agent (C). For example, the content may be 50 parts by mass or less, 40 parts by mass or less, 35 parts by mass or less, or 30 parts by mass or less.

[0111]

The total content of the coating film-forming resin (A) and the crosslinking agent (C) in the solid component of the coating composition is preferably 30% by mass or more, more preferably 40% by mass or more, still more preferably 50% by mass or more, and is preferably 95% by mass or less, more preferably 90% by mass or less, still more preferably 85% by mass or less, and further preferably 80% by mass or less.

[0112]

[Solvent (D)]

The coating composition may further comprise a solvent (D). The solvent preferably comprises an aqueous medium (D1) and/or an organic solvent (D2).

[0113]

Examples of the aqueous medium (D1) comprise water, a hydrophilic solvent, and a mixture of water and a hydrophilic solvent.

[0114]

Examples of the hydrophilic solvent comprise glycol-based solvents such as ethylene glycol, propylene glycol, butanediol, pentanediol, diethylene glycol, dipropylene glycol, and triethylene glycol; glycol ether-based solvents such as ethylene glycol monobutyl ether (butyl cellosolve), diethylene glycol monobutyl ether, diethylene glycol dibutyl ether, triethylene glycol monoethyl ether, propylene glycol monomethyl ether, propylene glycol monoethyl ether, propylene glycol monopropyl ether, dipropylene glycol monomethyl ether, dipropylene glycol monoethyl ether, and propylene glycol monomethyl ether acetate; alcohol-based solvents such as methanol, ethanol, and isopropyl alcohol; ketone-based solvents such as acetone; and N-methyl-2-pyrrolidone. Use of such a hydrophilic solvent offers an advantage that the wettability of the resulting coating composition with a substrate is improved.

[0115]

Examples of the organic solvent (D2) comprise ether solvents such as dioxane and tetrahydrofuran; ester solvents such as 3-methoxybutyl acetate, ethyl acetate, isopropyl acetate, and butyl acetate; ketone solvents such as methyl ethyl ketone, methyl isobutyl ketone, cyclohexanone, and isophorone; aromatic hydrocarbon-based solvents such as toluene, T-SOL 100, and T-SOL 150 (all manufactured by Exxon Chemical Co., Ltd.); hydrocarbon-based solvents such as pentane, isopentane, hexane, isohexane, and cyclohexane; and mineral oils such as solvent naphtha and mineral spirits. These may be used singly, or two or more of them may be used in combination.

[0116]

The coating composition may be an aqueous coating composition mainly containing an aqueous medium (D1) as the solvent (D), or may be a solvent-based coating composition mainly containing an organic solvent (D2) as the solvent (D).

When the coating composition is an aqueous coating composition, the content of the aqueous medium (D1) in the solvent (D) is preferably 50% by mass or more, more preferably 70% by mass or more, and is preferably 100% by mass or less. When the coating composition is a solvent-based coating composition, the content of the organic solvent (D2) in the solvent (D) is preferably 50% by mass or more, more preferably 70% by mass or more, and is preferably 100% by mass or less.

[0117]

The content of the solvent (D) in the coating composition is preferably 0% by mass or more, more preferably 10% by mass or more, and still more preferably 30% by mass or more, and is preferably 70% by mass or less, and more preferably 60% by mass or less.

[0118]

The coating composition may be a water-borne coating material, or may be an organic solvent-based coating material, or may be a solvent-free coating material, for example, a powder coating material.

[0119]

The coating composition may further comprise other additives. Examples of such other additives comprise surface conditioning agents; extender pigments; colorants such as dyes; waxes; luster pigments; fillers (especially, particulate fillers, or the like); ultraviolet absorbers (benzophenone-based ultraviolet absorbers or the like); antioxidants (phenol-based, sulfid-based, hindered amine-based antioxidants, or the like); plasticizers; coupling agents (silane-based, titanium-based, and zirconium-based coupling agents, or the like); anti-sagging agents; viscosity control agents; pigment dispersants; pigment wetting agents; leveling agents; anti-flooding agents; anti-settling agents; anti-foaming agents; anti-freezing agents; emulsifiers; preservatives; antifungal

agents; antimicrobial agents; and stabilizers. These additives may be used singly or two or more of them may be used in combination.

[0120]

Examples of the luster pigment comprise mica and metal foils such as aluminum foil, tin foil, gold foil, silver foil, titanium gold foil, stainless steel foil, and nickel-copper.

[0121]

Examples of the filler comprise fine particles of SiO_2 , TiO_2 , Al_2O_3 , Cr_2O_3 , ZrO_2 , $\text{Al}_2\text{O}_3 \cdot \text{SiO}_2$, $3\text{Al}_2\text{O}_3 \cdot 2\text{SiO}_2$, zirconia silicate, or ceramic beads; fibrous or granular fine glass; glass beads; and resin beads. Examples of the resin constituting the resin beads comprise acrylic resin, urethane resin, polyester resin, polyamide resin, polystyrene resin, polyethylene resin, melamine resin, urea resin, fluororesin, and polyacrylonitrile resin. The fine particle shape means a granular shape, a spherical shape, or a hollow spherical shape. The resin beads are preferably in a spherical shape.

[0122]

The average particle size of the filler may be, for example, 100 nm or more, or 500 nm or more. The average particle size may be 500 μm or less, or 200 μm or less. In the present description, the average particle size means a volume average particle size (D50), and can be measured using a laser Doppler particle size analyzer (for example, Microtrac UPA150 manufactured by Nikkiso Co., Ltd.).

[0123]

The coating composition can be prepared by dissolving or dispersing the coating film-forming resin (A), the pigment (B) and, optionally, the crosslinking agent (C) and other additives in the solvent (D), which is also optionally used. The mixing order of the materials to be used is not particularly limited, and for example, the coating

composition may be produced by mixing the pigment (B) and a portion of the coating film-forming resin (A) in advance to form a pigment paste, and then mixing the pigment paste with the remaining ingredient and other ingredients to be used as necessary. The coating composition of the present description can be prepared by mixing the ingredients using a selected mixing machine, dispersing machine, kneading machine, or the like, such as a sand grind mill, a ball mill, a blender, a paint shaker, or a disper.

[0124]

In the coating film obtained from the coating composition, the lightness (L^* value) may be 80 or less, for example, 70 or less. In addition, for example, the lightness may be 5 or more, or 15 or more.

[0125]

The lightness of the coating film can be measured, for example, using a spectrophotometer in accordance with JIS K 5600-4-4, 3.2 and JIS K 5600-4-5. The lightness can be measured using, for example, CM-600d (manufactured by Konica Minolta, Inc.) as a spectrophotometer.

[0126]

In the present description, a coating film for measuring lightness, near-infrared reflectance, and spectral reflectance can be formed, for example, by the following method.

The coating composition is applied to a black-and-white hiding ratio test paper (manufactured by Nippon Testpanel Co., Ltd.) as a base such that the thickness after drying is 30 μm or more and 2,000 μm or less, and heated at a heating temperature of 20°C or more and 200°C or less for 10 minutes or more and 24 hours or less. Thus, a dry coating film is obtained. The part where the lightness (L^* value) is to be measured may be a part of the obtained dry coating film where the base is white.

[0127]

Since the wavelength region of near-infrared radiation is close to the visible light range, a coating composition having high near-infrared reflectance tends to have high reflectance of visible light and high lightness. In general, when the lightness (L^* value) is less than 80, the near-infrared reflectance tends to decrease, and the LiDAR visibility tends to decrease. However, since the coating composition described above has the configuration described above, it is easy to increase the near-infrared reflectance while lowering the lightness.

[0128]

The lightness of the coating composition measured by the method described above may be, for example, 90 or less, or 80 or less. In addition, the lightness may be 3 or more, or 5 or more.

[0129]

In the coating film obtained from the coating composition, the arithmetic mean height (S_a) is preferably 1 μm or more, or the root mean square height (S_q) is preferably 1 μm or more. More preferably, S_a is 3 μm or more, or S_q is 5 μm or more, and more preferably, S_a is 5 μm or more, or S_q is 10 μm or more. Within such ranges, there is an advantage that the LiDAR visibility is good.

[0130]

The surface roughness of the coating film can be measured in accordance with JIS B 0601. The arithmetic mean height and the root mean square height are respectively calculated on the basis of the surface roughness measurement, and defined as the arithmetic mean height (S_a) and the root mean square height (S_q) of the coating film. The surface roughness can be measured using, for example, a laser microscope (for example, a laser microscope VK-X200 manufactured by KEYENCE Corporation).

[0131]

The arithmetic mean height (also referred to as “Sa”) is a parameter indicating the roughness of the surface of the coating film, and represents the average of absolute values of differences in height at respective points with respect to the average plane of the surface of the coating film. When Sa is small, it means that the coating film surface is flatter, whereas when Sa is large, it means that the coating film surface has larger irregularities. The root mean square height (also referred to as “Sq”) is a parameter corresponding to the standard deviation of the distance from the average plane of the surface of the coating film.

[0132]

The coating film can be formed, for example, by the following method.

The coating composition is applied to a tin plate (manufactured by TP Giken Co., Ltd.) such that the thickness after drying is 30 μm or more and 2,000 μm or less, and heated at a heating temperature of 20°C or more and 200°C or less for 10 minutes or more and 24 hours or less. Thus, a dry coating film is obtained.

[0133]

The coating film formed from the coating composition is also included in the technical scope of the present disclosure.

[0134]

The near-infrared reflectance of the coating film is preferably 15% or more, more preferably 30% or more, and still more preferably 35% or more, and for example, it is acceptable that the near-infrared reflectance is 99% or less, or 90% or less.

[0135]

The spectral reflectance of the coating film at a wavelength of 905 nm and/or 1,550 nm is preferably 20% or more, more preferably 30% or more, further preferably 35% or more, and for example, 99% or less, further 90% or less is also acceptable.

[0136]

The near-infrared reflectance and the spectral reflectance at a wavelength of 950 nm and/or 1,550 nm of the coating film can be measured, for example, according to the same method as the method described for measuring the near-infrared reflectance of a coating film containing a pigment in the measurement of the near-infrared reflectance of the pigment.

[0137]

The coating film can be formed, for example, by the following method.

The coating composition is applied to a black-and-white hiding ratio test paper (manufactured by Nippon Testpanel Co., Ltd.) as a base such that the thickness after drying is 30 μm or more and 2,000 μm or less, and heated at a heating temperature of 20°C or more and 200°C or less for 10 minutes or more and 24 hours or less. Thus, a dry coating film is obtained.

[0138]

Examples of the article to be coated with the coating film comprise a metal plate, a member formed of a metal plate, a plastic member, an inorganic material member, a wooden member, and a paved body such as a road surface.

[0139]

Examples of the metal plate comprise metal plates such as a galvanized steel plate, a zinc-aluminum alloy plated steel plate, an aluminum alloy plated steel plate, a hot-dip zinc-aluminum-magnesium alloy plated steel plate, a stainless steel plate, and a cold rolled steel plate each manufactured by a melting method, an electrolytic method or

the like. In addition to these steel plates or plated steel plates, a metal plate such as an aluminum plate (including an aluminum alloy plate) can also be a coating target. The metal plate is preferably surface-treated. Specifically, the metal plate preferably has been subjected to chemical conversion treatment after being subjected to pretreatment such as alkali degreasing treatment, hot water washing treatment, or water washing treatment. The chemical conversion treatment may be carried out by a publicly known method, and examples thereof comprise chromate treatment and non-chromate treatment such as zinc phosphate treatment. While the surface treatment may be appropriately selected according to the steel sheet to be used, treatment free of heavy metals is preferable.

[0140]

Examples of the plastic member comprise acrylic plate, polyvinyl chloride plate, polycarbonate plate, ABS plate, polyethylene terephthalate plate, and polyolefin plate.

[0141]

Examples of the inorganic member comprise ceramic building materials and glass substrates described in JIS A 5422, JIS A 5430, and the like, and, for example, calcium silicate plate, pulp cement plate, slag gypsum plate, magnesium carbonate plate, asbestos pearlite plate, wood cement plate, hard wood cement plate, concrete plate, and lightweight cellular concrete plate.

[0142]

Examples of the wooden member comprise conversion lumber, laminated wood, plywood, particle board, fiber board, improved wood, chemical treated wood, and floorboard.

[0143]

Examples of the paved body such as a road surface comprise asphalt pavement, concrete pavement, and brick pavement.

[0144]

Specific examples of the article to be coated comprise a structure, an article, and the like that can serve as an obstacle in autonomous driving of an automobile. Examples thereof comprise various commercial products to be sold, traveling roads, road structures [for example, pavement, road marking, sidewalk, pedestrian crossing, drainage facility, planar intersection structure, bridge, earthmoving, tunnel, refuge, traffic safety facility (for example, a stereoscopic crossing facility, a guardrail, a guard pole, a guard fence, a lighting facility, a visual guide, and a traffic mirror), traffic island, stop, parking zone, and parking lot], various building structures and internal facilities thereof, railway structures, various protection facilities, various vehicles and accessories thereof, pedestrian wears, utility poles, and inner walls of building structures.

[0145]

The coating film can be formed by applying the coating composition to an article to be coated to form an applied film, and drying and/or curing the applied film at normal temperature or by heating the applied film, as necessary.

[0146]

The application can be performed by, for example, a coating method such as a spray coating method, a bar coater coating method, an air knife coating method, a gravure coating method, a brush coating method, an air gun coating method, an air electrostatic gun coating method, or a dip coating method.

[0147]

The thickness of the coating film may be set to, for example, 10 to 100 μm .

[0148]

When the applied film is heated to be dried and/or cured, the heating temperature is, for example, preferably 70 to 180°C, and more preferably 80 to 140°C. The heating time is, for example, preferably 10 to 60 minutes, and more preferably 15 to 45 minutes. As the heating means, hot air heating, infrared ray heating, induction heating, or the like may be employed.

[0149]

Furthermore, a sensing method using near-infrared light using the coating film is also included in the technical scope of the present disclosure.

For example, in a sensing method for measuring a distance between a vehicle and a coated object, the method including: emitting near-infrared radiation having a specific wavelength from a traveling vehicle, reflecting the near-infrared radiation on a detection target, detecting the reflected light, and calculating the distance from the vehicle to the coated detection target on the basis of a time required for reflection [Time-of-Flight (ToF) method], the coated object may be an article obtained through application of the coating composition described above. Further, in a sensing method for measuring a distance between a vehicle and a coated object, the method including: emitting near-infrared radiation having a specific wavelength from a traveling vehicle, reflecting the near-infrared radiation on a detection target, detecting the reflected light, and calculating the distance from the vehicle to the detection target from a change in frequency difference between the emitted light and the reflected light [Frequency Modulated Continuous Wave (FMCW) method], the coated object may be an article obtained through application of the coating composition described above.

[0150]

The coating composition and the coating film described above are useful as a coating material and a coating film for a detection target of sensing using near-infrared

light because the coating composition and the coating film are capable of enhancing the near-infrared detection accuracy in the LiDAR technology, and preferably capable of enhancing the near-infrared detection accuracy in the LiDAR technology while having low lightness.

EXAMPLES

[0151]

The present disclosure will be described more specifically with reference to the following examples, but the present invention is not limited to them.

[0152]

<Measurement Example 1 of near-infrared reflectance and spectral reflectance of pigment>

Example of measurement of near-infrared reflectance and spectral reflectance at wavelength of 905 nm and/or 1,550 nm of inorganic red pigment

(A-1) AROSET 5534-SB60 (21 parts by mass) as a coating film-forming resin, 6 parts by mass of (D2-1) T-SOL 100 (manufactured by ExxonMobil Chemical Ltd.) as a solvent, and 22 parts by mass of (B21-1) Toda Color 120ED as an inorganic red pigment were mixed, and then dispersed using an SG mill (medium: glass beads) until the dispersion particle size of the pigment was adjusted to 10 μm or less. Next, 51 parts by mass of (A-1) was added, and the resulting mixture was mixed while being stirred using a disper, affording a base agent.

[0153]

A curing agent was obtained by mixing 62 parts by mass of (C-1) DURANATE TSA-100 as a crosslinking agent and 38 parts by mass of T-SOL 100 (manufactured by Exxon Chemical Co., Ltd.) as a solvent (D2-1) while stirring with a disper.

[0154]

The base agent and the curing agent obtained as described above were mixed at a mass ratio of 9:1, affording a coating composition (pigment mass concentration: 30% by mass). The coating composition obtained was applied to a black-and-white hiding ratio test paper (manufactured by Nippon Testpanel Co., Ltd.) using an 8 mil doctor blade such that the dry film thickness was 50 μm , dried at 60°C for 20 minutes, and then allowed to stand at normal temperature for one day, affording a coating film.

[0155]

For the coating film obtained, a part where the base was white was measured for reflectance in a wavelength region of 800 to 2,500 nm every 2 nm by a method in accordance with JIS K-5602 using a spectrophotometer (SHIMADZU-UV3600 manufactured by Shimadzu Corporation). The arithmetic average value of the reflectance obtained at the respective wavelengths was taken as the near-infrared reflectance of the inorganic red pigment. The near-infrared reflectance at 905 and 1,550 nm is the spectral reflectance values at the respective wavelengths.

[0156]

The near-infrared reflectance and spectral reflectance of each of the other pigments were measured in the same manner as in Measurement Example 1 of the near-infrared reflectance and spectral reflectance of the pigment described above except that the type and pigment mass concentration of each pigment were changed to the amounts given in Table 1.

[0157]

[Table 1]

Coloring pigment (B)		(B21-1)	(B22-1)	(B31-1)	(B32-1)	(B4-1)
Hue		Chromatic	Chromatic	Chromatic	Chromatic	Chromatic
Hue		Inorganic red	Organic red	Inorganic yellow	Organic yellow	Blue
Type of pigment (Commercial product name)		Toda Color 120ED	CINILEX DPP RED SR1C	Sicopal Yellow L-1110	Symuler Fast Yellow 4192	Fastogen Blue 9453
Name of manufacturer		Toda Kogyo Corp.	CINIC Chemicals	Toda Kogyo Corp.	DIC Corporation	DIC Corporation
Pigment mass concentration (PWC) (%)		30	25	30	25	20
Near-infrared reflectance (%)	Wavelength 800 to 2,500 nm	60	55	55	65	55
	Wavelength 905 nm	30	70	25	85	45
Spectral reflectance (%)	Wavelength 1,550 nm	75	60	70	70	70
Coloring pigment (B) or (b)		(B1-1)	(B51-1)	(B52-1)	(b1)	
Hue		Achromatic	Achromatic	Achromatic	Achromatic	
Hue		White	Inorganic black	Organic black	Organic black	
Type of pigment (Commercial product name)		TIPAQUE CR-97	Daipyroxide Color Black 9590	Chromofine Black A-1103	BLACK MA-200	
Name of manufacturer		Ishihara Sangyo Kaisha, Ltd.	Dainichiseika Color & Chemicals Mfg. Co., Ltd.	Dainichiseika Color & Chemicals Mfg. Co., Ltd.	Mitsubishi Chemical Corporation	
Pigment mass concentration (PWC) (%)		45	50	3	10	
Near-infrared reflectance (%)	Wavelength 800 to 2,500 nm	75	45	45	4	
	Wavelength 905 nm	90	20	75	5	
Spectral reflectance (%)	Wavelength 1,550 nm	80	65	60	4	

[0158]

<Production Example 1>

Production Example of white pigment paste

(A-1) AROSET 5534-SB60 (22 parts by mass) as a coating film-forming resin, 7 parts by mass of (D2-1) T-SOL 100 (manufactured by ExxonMobil Chemical Ltd.) as a solvent, and 34 parts by mass of (B1-1) TIPAQUE CR-97 as a white pigment were mixed, and then dispersed using an SG mill (medium: glass beads) until the dispersion

particle size of the pigment was adjusted to 10 μm or less. Next, 37 parts by mass of (A-1) was added, and the resulting mixture was mixed while being stirred using a disper, affording a white pigment paste (W-1).

[0159]

<Production Examples 2 to 9>

Pigment pastes of respective pigments were obtained in the same manner as in Production Example 1 except that the types and amounts of the coating film-forming resin, the solvent and the pigment to be used were changed as given in Table 2.

[0160]

[Table 2]

Pigment paste		(R1-1)	(R2-1)	(Y1-1)	(Y2-1)	(Bu-1)
Coloring pigment (B)	Type	(B21-1)	(B22-1)	(B31-1)	(B32-1)	(B4-1)
Hue		Chromatic	Chromatic	Chromatic	Chromatic	Chromatic
Hue		Inorganic red	Organic red	Inorganic yellow	Organic yellow	Blue
Type of pigment (Commercial product name)		Toda Color 120ED	CINILEX DPP RED SR1C	Sicopal Yellow L-1110	Symuler Fast Yellow 4192	Fastogen Blue 9453
Blending amount (parts by mass)						
Coloring pigment (B)		22.0	17.0	22.0	16.0	13.0
Coating film-forming resin	(A-1)	72.0	71.0	72.0	70.0	74.0
Solvent	(D2-1)	6.0	12.0	6.0	14.0	13.0
Total (parts by mass)		100.0	100.0	100.0	100.0	100.0
Pigment mass concentration	Mass (%)	33.7	28.5	33.7	27.6	22.6

Pigment paste		(W-1)	(BK1-1)	(BK2-1)	(bk-1)
Coloring pigment (B)	Type	(B1-1)	(B51-1)	(B52-1)	(b1)
Hue		Achromatic	Achromatic	Achromatic	Achromatic
Hue		White	Inorganic black	Organic black	Organic black
Type of pigment (Commercial product name)		TIPAQUE CR-97	Daipyroxide Color Black 9590	Chromofine Black A-1103	BLACK MA-200
Blending amount (parts by mass)					
Coloring pigment (B) or (b)		34.0	39.0	2.0	5.0
Coating film-forming resin	(A-1)	59.0	53.0	84.0	61.0
Solvent	(D2-1)	7.0	8.0	14.0	34.0
Total (parts by mass)		100.0	100.0	100.0	100.0
Pigment mass concentration	Mass (%)	49.0	55.1	3.8	12.0

[0161]

<Production Example of clear for PWC adjustment>

A clear for PWC adjustment was obtained by mixing 83 parts by mass of (A-1) AROSET 5534-SB60 as a coating film-forming resin and 17 parts by mass of (D2-1) T-SOL 100 (manufactured by ExxonMobil Chemical Ltd.) as a solvent were while stirring with a disper.

[0162]

<Example 1>

A base agent (S-1) was obtained by mixing 126.1 parts by mass of the white pigment paste (W-1) and 23.8 parts by mass of the clear for PWC adjustment while stirring with a disper.

[0163]

A curing agent (K-1) was obtained by mixing 62 parts by mass of (C-1) DURANATE TSA-100 as a crosslinking agent and 38 parts by mass of T-SOL 100 (manufactured by ExxonMobil Chemical Ltd.) as a solvent while stirring with a disper.

[0164]

<Production Example 1 of coating film (test piece)>

Coating composition 1 (pigment mass concentration: 42% by mass) was obtained by mixing 149.9 parts by mass of the base agent (S-1) and 16.7 parts by mass of the curing agent (K-1) while stirring with a disper. The coating composition 1 obtained was applied to a black-and-white hiding ratio test paper (manufactured by Nippon Testpanel Co., Ltd.) such that the dry film thickness was 100 μm , dried at 60°C for 20 minutes, and then allowed to stand at normal temperature for one day, affording test piece 1. The base agent (S-1) and the curing agent (K-1) were set to 9:1 in mass ratio.

[0165]

Each coating film (test piece) was obtained in the same manner as in Production Example 1 of the coating film (test piece) except that the type and amount of the pigment paste, the clear for PWC adjustment, the crosslinking agent, and the solvent used were changed as given in Table 3.

When other materials were contained in the coating composition, the other materials were mixed together with various pigment pastes and a clear for PWC adjustment at the time of producing the base agent, and thus the base agent was prepared.

[0166]

Details of each component given in the following tables used in Examples and Comparative Examples are as follows.

Coating film-forming resin (A)

(A-1) AROSET 5534-SB60 (acrylic polyol resin, manufactured by Nippon Shokubai Co., Ltd.): weight average molecular weight: 50,000, acid value: 10 mg KOH/g, hydroxyl value: 38 mg KOH/g, solid concentration: 60% by mass

Crosslinking agent (C)

(C-1) DURANATE TSA-100 (HDI isocyanurate type polyisocyanate, manufactured by Asahi Kasei Corporation); NCO content: 20.6%, solid concentration: 100% by mass

Solvent (D)

(D2-1) T-SOL 100 (aromatic hydrocarbon-based solvent, manufactured by ExxonMobil Chemical Ltd.)

Other materials:

Filler: Gasil HP395 (amorphous silica, manufactured by PQ Corporation); average particle size: 14.5 μm

[0167]

A base agent and a curing agent were prepared and a test piece was obtained in the same manner as in Example 1 except that the types and amounts of respective components were changed as given in the following table.

[0168]

<Evaluation method>

1) Coating film lightness

The lightness (L^* value) of the coating film surface of each of the test pieces obtained in Examples and Comparative Examples was measured in accordance with JIS K 5600-4-4, 3.2 and JIS K 5600-4-5 using a spectrophotometer CM-500 (manufactured by Konica Minolta, Inc.).

[0169]

2) Near-infrared reflectance and spectral reflectance

For each of the test pieces obtained in Examples and Comparative Examples, a part where the base was white was measured for reflectance in a wavelength region of 800 to 2,500 nm every 2 nm by a method in accordance with JIS K-5602 using a spectrophotometer (SHIMADZU-UV3600 manufactured by Shimadzu Corporation). The arithmetic average value of the reflectance obtained at the respective wavelengths was taken as the near-infrared reflectance of the coating film. The near-infrared reflectance at 905 and 1,550 nm is the spectral reflectance values at the respective wavelengths.

[0170]

3) Surface roughness

The arithmetic mean height (S_a : μm) and the root mean square height (S_q : μm) of the coating film surface of each of the test pieces obtained in Examples and

Comparative Examples were measured in accordance with JIS B 0601 using a laser microscope VK-X200 (manufactured by KEYENCE Corporation).

[0171]

4) LiDAR visibility

Each of the test pieces obtained in Examples and Comparative Examples was observed from a point 3 m away using a LiDAR Mid-40 (manufactured by Livox Technology Co., Ltd., wavelength: 905 nm). The state of the test piece obtained in an imaging image was visually observed, and the reflectance was measured at 10 points arbitrarily selected on the entire test piece. The arithmetic average value of the measurements was taken as the LiDAR reflectance of the test piece, and evaluation was performed according to the following criteria. Score 3 or more was regarded as acceptable.

- 5: The LiDAR reflectance of the test piece is 100 or more
- 4: The LiDAR reflectance of the test piece is 50 or more and less than 100
- 3: The LiDAR reflectance of the test piece is 30 or more and less than 50
- 2: The LiDAR reflectance of the test piece is 10 or more and less than 30
- 1: The LiDAR reflectance of the test piece is less than 10

[0172]

[Table 3]

		Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9	Example 10	Example 11	Comparative Example 1	Comparative Example 2
Base agent														
Pigment paste														
Red pigment paste	(R1-1)		0.5	19.1										
	(R2-1)				12.9	18.4	24.3	18.4	18.4					
Yellow pigment paste	(Y1-1)		1.1	8.5						0.6				
	(Y2-1)				22.6	25.8	11.7	25.8	25.8					
Blue pigment paste	(Bu-1)		0.2	0.5	5.1	16.2	0.5	16.2	16.2					
White pigment paste	(W-1)	126.1	103.6	79.9	12.8		79.9			38.7	123.6	109.8		
Black pigment paste	(BK1-1)													
	(BK2-1)									33.7				
Other pigment paste	(bk-1)												160.3	48.1
Other material	Amorphous silica							5.0	10.0	2.3	5.1	10.6		
Clear for PWC adjustment		23.8	47.3	46.2	113.2	108.7	40.8	100.3	92.0	89.2	22.1	33.0	27.8	125.0
Total of base agent (parts by mass)		149.9	152.8	154.2	166.6	169.1	157.0	165.7	162.4	164.4	150.9	153.4	188.0	173.1
Curing agent														
Crosslinking agent (C)	(C-1)	10.3	10.5	10.6	11.5	11.6	10.8	11.4	11.2	11.3	10.4	10.6	13.0	11.9
Solvent (D)	(D2-1)	6.3	6.4	6.5	7.0	7.1	6.6	7.0	6.9	6.9	6.4	6.5	7.9	7.3
Total of curing agent (parts by mass)		16.7	17.0	17.1	18.5	18.8	17.4	18.4	18.0	18.3	16.8	17.0	20.9	19.2
Total of base agent + curing agent (parts by mass)		176.7	180.0	178.4	194.1	196.1	180.8	187.1	178.2	191.6	177.9	180.9	194.0	195.8
Pigment mass concentration (% by mass) of coloring pigment (B)														
Inorganic red pigment	(B21-1)		0.11	4.15										
Organic red pigment	(B22-1)				2.21	3.15	4.15	3.15	3.15					
Inorganic yellow pigment	(B31-1)		0.23	1.86						0.13				
Organic yellow pigment	(B32-1)				3.60	4.11	1.86	4.11	4.11					
Blue pigment	(B4-1)		0.03	0.06	0.67	2.13	0.06	2.13	2.13					
White pigment	(B1-1)	42.00	34.53	26.62	4.26		26.62			12.90	41.20	36.60		
Inorganic black pigment	(B51-1)													
Organic black pigment	(B52-1)									0.70				
Other pigment	(b1)										0.32	0.66	10.00	3.00
Total pigment mass concentration (% by mass) of coloring pigment (B)		42.00	34.90	32.69	10.74	9.39	32.69	14.39	19.39	16.00	41.52	37.26	10.00	3.00
Evaluation	Lightness (L* value)	96	86	59	25	10	60	10	10	45	69	60	5	10
	Near-infrared reflectance (%)													
	800 to 2,500 nm	81	80	66	54	43	65	43	43	50	23	16	3	3
	Spectral reflectance (%)													
	905 nm	96	90	65	73	60	85	65	70	78	33	23	3	3
	1,550 nm	85	76	78	56	50	75	50	50	64	21	14	3	3
	Surface roughness													
	Sa (μm)	0.6	0.6	0.6	0.6	0.6	0.6	3.0	5.0	2.0	0.6	0.6	0.6	0.6
	Sq (μm)	0.8	0.8	0.8	0.8	0.8	0.8	3.0	10.0	2.0	0.8	0.8	0.8	0.8
LiDAR visibility		5	5	4	5	4	5	5	5	5	4	3	1	1

[0173]

Examples 1 to 11 are examples of the present disclosure, in which the detection accuracy in the LiDAR technology was high, and in particular, even when the lightness (L* value) was low, the detection accuracy in the LiDAR technology was high.

[0174]

Comparative Examples 1 and 2 are examples in which none of a white pigment having a near-infrared reflectance of 60% or more, a chromatic pigment having a near-infrared reflectance of 50% or more, and a black pigment having a near-infrared

reflectance of 30% or more is contained as a pigment, and it was possible to reduce the lightness, but the detection accuracy in the LiDAR technology was not sufficiently satisfactory.

INDUSTRIAL APPLICABILITY

[0175]

The coating composition and the coating film of the present disclosure are useful as a coating material and a coating film for a detection target in the LiDAR technology because the coating composition and the coating film are capable of enhancing the near-infrared detection accuracy in the LiDAR technology, and preferably capable of enhancing the near-infrared detection accuracy in the LiDAR technology while having low lightness.

CLAIMS

1. A coating composition for a detection target of sensing using near-infrared light, comprising: a coating film-forming resin (A); and a coloring pigment (B),
wherein the coloring pigment (B) comprises at least one pigment selected from the group consisting of a white pigment having a near-infrared reflectance of 60% or more, a chromatic pigment having a near-infrared reflectance of 50% or more, and a black pigment having a near-infrared reflectance of 30% or more, and
wherein a near-infrared reflectance is defined as a reflectance in a wavelength region of 800 to 2,500 nm.
2. The coating composition for a detection target of sensing using near-infrared light according to claim 1, wherein the chromatic pigment comprises at least one pigment selected from the group consisting of a red pigment, a yellow pigment, and a blue pigment.
3. The coating composition for a detection target of sensing using near-infrared light according to claim 1 or 2, wherein the red pigment and the yellow pigment each comprise an organic pigment and/or an inorganic pigment.
4. The coating composition for a detection target of sensing using near-infrared light according to any one of claims 1 to 3,
wherein the coloring pigment (B) comprises at least one pigment selected from the group consisting of:
a white pigment having a spectral reflectance of 70% or more at a wavelength of 905 nm and/or 1,550 nm;
an organic red pigment having a spectral reflectance of 50% or more at the above-specified wavelength;

an inorganic red pigment having a spectral reflectance of 20% or more at the above-specified wavelength;

an organic yellow pigment having a spectral reflectance of 60% or more at the above-specified wavelength;

an inorganic yellow pigment having a spectral reflectance of 20% or more at the above-specified wavelength;

a blue pigment having a spectral reflectance of 40% or more at the above-specified wavelength;

an organic black pigment having a spectral reflectance of 30% or more at the above-specified wavelength; and

an inorganic black pigment having a spectral reflectance of 15% or more at the above-specified wavelength.

5. The coating composition for a detection target of sensing using near-infrared light according to any one of claims 1 to 4, wherein a coating film to be formed has a lightness of 80 or less.

6. A coating film for a detection target of sensing using near-infrared light, having a near-infrared reflectance of 15% or more in a wavelength region of 800 to 2,500 nm.

7. A coating film for a detection target of sensing using near-infrared light, the coating film being formed from the coating composition according to any one of claims 1 to 5.

8. The coating film for a detection target of sensing using near-infrared light according to claim 7, having a near-infrared reflectance 15% or more in a wavelength region of 800 to 2,500 nm of.

9. The coating film for a detection target of sensing using near-infrared light according to any one of claims 6 to 8, wherein the coating film has a spectral reflectance of 20% or more at a wavelength of 905 nm and/or 1,550 nm.

10. A detection target having a coating film formed using the coating composition for a detection target of sensing according to any one of claims 1 to 5.

11. A sensing method for measuring a distance between a vehicle and a detection target, wherein the method comprises: emitting near-infrared radiation having a specific wavelength from a traveling vehicle; reflecting the near-infrared radiation on the detection target; detecting light reflected on the detection target; and calculating the distance from the vehicle to the detection target on a basis of a time required for reflection,

wherein the coated object is obtained by applying the coating composition according to any one of claims 1 to 5.

12. A sensing method for measuring a distance between a vehicle and a detection target, wherein the method comprises: emitting near-infrared radiation having a specific wavelength from a traveling vehicle; reflecting the near-infrared radiation on the detection target; detecting light reflected on the detection target; and calculating the distance from the vehicle to the detection target on a basis of a difference in frequency between emitted light and reflected light,

wherein the coated object is obtained by applying the coating composition according to any one of claims 1 to 5.