DESCRIPTION

Title of Invention: LOW-TEMPERATURE CURABLE CLEAR COATING COMPOSITION

TECHNICAL FIELD

[0001] The present invention relates to a low-temperature curable clear coating composition which may be cured at a low temperature, is inexpensive to manufacture, and has excellent appearance characteristics of a produced coating film.

BACKGROUND ART

[0002] In general, a car body outer plate should not have deterioration and rust occurrence of a coating film, and should have durability to maintain gloss or color of the coating film. Therefore, a painting process of vehicles is usually performed by electrodeposition painting a car body after a pretreatment process, performing middle painting for improving adhesion and smoothness, and performing base painting on the middle-painted car body for aesthetics of the car body. Thereafter, in order to protect the color of the base coating film, improve the appearance thereof, and protect the base coating film from the outside, it is common to paint a clear coating film.

[0003] As a conventional clear paint for automobiles, a thermosetting coating composition of a resin including a hydroxyl group and an amino resin is widely used. However, when the conventional thermosetting coating composition is used, parts composed of plastic materials such as bumpers and rearview mirrors may have a disfigured appearance or distortion when cured under curing conditions at a high

temperature, and thus, there is inconvenience of separating the parts from the car body and performing a separate painting process. In addition, the color of the plastic material part which has been separated from the car body and separately painted and the color of the car body become different. Thus, a low-temperature curable clear coating composition which has a lowered curing temperature so that the painting process is performed with the plastic material parts being integrated into the car body is attracting attention.

[0004] As an alternative thereto, Korean Patent Registration No. 1,655,621 (Patent Document 1) discloses a clear coating composition including two acrylic polyol resins, a polyester polyol resin, a reactive silicon additive, and an isocyanate curing agent. However, since a conventional low-temperature curable clear coating composition such as the clear coating composition of Patent Document 1 has insufficient mechanical properties of the coating film produced therefrom, it may be applied only for repair or painting of parts and there is a limitation in application for painting of a car body.

[0005] Therefore, there is a need for research and development on a clear coating composition which is curable at a low temperature of 120°C or lower and has excellent mechanical properties of the coating film produced therefrom, and thus, is appropriate for application for painting of a car body.

DISCLOSURE OF THE INVENTION

TECHNICAL PROBLEM

[0006] The present invention provides a clear coating composition which is curable at a low temperature of 120°C or

lower and may produce a coating film having excellent mechanical properties.

TECHNICAL SOLUTION

[0007] The present invention provides a low-temperature curable clear coating composition including: an acryl resin, a first polyester resin, a second polyester resin, and an isocyanate-based curing agent,

[0008] wherein the first polyester resin has a hydroxyl value of 240 to 320 mg KOH/g, and

[0009] the second polyester resin has a hydroxyl value of 100 to 180 mg KOH/g.

ADVANTAGEOUS EFFECTS

[0010] Since the clear coating composition according to the present invention is curable at a low temperature at 120°C or lower and may reduce energy costs of a painting process, it is economical, and since it may paint a car body and material parts attached thereto integrally, it may prevent a problem of having different colors between the parts and the car body after painting. In addition, since it may paint both a car body and parts with one painting process, inconvenience in the process and cost loss may be reduced. Furthermore, since a coating film produced from the clear coating composition has excellent mechanical properties such as hardness, adhesion, water resistance, acid resistance, scratch resistance, and solvent resistance, it may be useful for car body painting.

MODE FOR CARRYING OUT THE INVENTION

[0011] Hereinafter, the present invention will be described in detail.

[0012] A "weight average molecular weight" and a "number

average molecular weight" used in the present specification were measured by a common method known in the art, and for example, may be measured by a method of gel permeation chromatograph (GPC).

[0013] In addition, a "glass transition temperature (Tg)" was measured by a method known in the art, and for example, may be measured by a method of differential scanning calorimetry (DSC).

[0014] A functional group value such as an "acid value" and a "hydroxyl value" may be measured by a method well-known in the art, and for example, may represent a value measured by a titration method and the like.

[0015] In addition, in the present specification, "(meth)acryl" refers to "acryl" and/or "methacryl", and (meth)acrylate" refers to "acrylate" and/or "methacrylate".

[0016] A low-temperature curable clear coating composition according to the present invention includes an acryl resin, a first polyester resin, a second polyester resin, and an isocyanate-based curing agent.

[0017] Acryl resin

[0018] The acryl resin serves to impart coating film formability and mechanical properties to a composition.

[0019] As the acryl resin, a product which was directly synthesized according to a known method may be used or a commercially available product may be used. For example, the acryl resin may be produced by polymerizing one or more of vinyl-based monomers and (meth)acrylate-based monomers.

[0020] Though the type of the vinyl-based monomer is not particularly limited, for example, one or more selected from the group consisting of styrene, methylstyrene,

dimethylstyrene, fluorostyrene, ethoxystyrene, methoxystyrene, phenylene vinyl ketone, vinyl t-butyl benzoate, vinyl cyclohexanoate, vinyl acetate, vinyl pyrrolidone, vinyl chloride, vinyl alcohol, acetoxystyrene, t-butylstyrene, and vinyltoluene may be used.

[0021] The (meth)acrylate-based monomer may include one or more selected from the group consisting of (meth)acrylate-based monomer containing no hydroxyl group and hydroxyl group-containing (meth)acrylate monomers.

[0022] The (meth)acrylate monomer containing no hydroxyl group may include, for example, one or more selected from the group consisting of (meth)acrylic acid, methyl (meth)acrylic acid, (meth)acrylate, methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, isopropyl (meth)acrylate, butyl (meth)acrylate, isobutyl (meth)acrylate, t-butyl (meth)acrylate, pentyl (meth)acrylate, hexyl (meth)acrylate, heptyl (meth)acrylate, isooctyl (meth)acrylate, octyl (meth)acrylate, 2-ethylhexyl (meth)acrylate, isodecyl (meth)acrylate, decyl (meth)acrylate, dodecyl (meth)acrylate, isobornyl (meth)acrylate, and lauryl (meth)acrylate.

[0023] The hydroxyl group-containing (meth)acrylate monomer may be, for example, hydroxyalkyl-containing (meth)acrylate, and specifically, may include one or more selected from the group consisting of 2-hydroxymethyl (meth)acrylate, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, and 2-hydroxybutyl (meth)acrylate.

[0024] For example, the acryl resin may be produced using a radical polymerization method, and the physical properties, that is, a weight average molecular weight (Mw), a hydroxyl

value (OHv), an acid value (Av), and the like may be adjusted depending on the initiator and a polymerization time.

[0025] In addition, the acryl resin may have a weight average molecular weight (Mw) of 10,000 to 40,000 g/mol, 15,000 to 35,000 g/mol, or 20,000 to 30,000 g/mol. When the weight average molecular weight of the acryl resin is within the range, the hardness of the produced coating film may be excellent. In addition, when the weight average molecular weight of the acryl resin is below the range, its molecular weight is so small that the water resistance and the chemical resistance of the produced coating film are insufficient, and when the weight average molecular weight is above the range, the viscosity is increased with an increased molecular weight, and the workability of the coating composition including the acryl resin becomes poor and the leveling properties are not good, so that it may be difficult to produce a coating film having excellent appearance.

[0026] In addition, the acryl resin may have a hydroxyl value (OHv) of 100 to 200 mg KOH/g, or 145 to 170 mg KOH/g. When the hydroxyl value of the acryl resin is within the range, there is an effect of improving the weather resistance of the coating film. In addition, when the hydroxyl value of the acryl resin is below the range, coating film formation by the crosslinking reaction with a curing agent is insufficient, so that the hardness, the water resistance, and the like of the coating film are deteriorated, and when it is above the range, overcuring occurs, so that the coating film becomes brittle and loses elasticity, and the appearance and the weather resistance of the produced coating film may be deteriorated.

[0027] The acryl resin may have an acid value (Av) of 5 to 15 mg KOH/g, or 8 to 11 mg KOH/g. When the acid value of the acryl resin is within the range, the water dispersibility and the storage stability of the coating composition may be improved and the water resistance may be improved. In addition, when the acid value of the acryl resin is below the range, a curing reaction rate is lowered to deteriorate the appearance of the produced coating film and the water dispersion stability of the resin, and when it is above the range, the viscosity of the composition is increased to deteriorate the workability and the water resistance of the coating film.

[0028] The acryl resin may have a glass transition temperature (Tg) of 20 to 100°C, 40 to 70°C, or 52 to 58°C. When the glass transition temperature of the acryl resin is within the range, the coating film formability and the defoamability of the composition and the gloss properties of the coating film are improved. In addition, when the glass transition temperature of the acryl resin is below the range, the drying speed and the crosslinking density of the coating film are decreased to deteriorate the impact resistance and the water resistance of the produced coating film, and when it is above the range, the coating film becomes brittle and its appearance and hardness may be lowered.

[0029] The acryl resin may have a solid content (NV) of 60 to 80 wt%, 65 to 75 wt%, or 68 to 73 wt%, with respect to the total weight of the resin. When the solid content of the acryl resin is within the range, the storage stability of the resin and the storage stability of the coating composition may be improved and workability may be excellent. In

addition, the solid content of the acryl resin is below the range, the viscosity is excessively low, so that the workability of the coating composition including the resin becomes insufficient, and when it is above the range, the viscosity of the acryl resin is excessively high so that stability during the reaction becomes poor, and dispersion stability is deteriorated so that agglomeration may occur over time.

[0030] In addition, the acryl resin may be included at a content of 15 to 35 wt% or 20 to 30 wt%, based on the total weight of the coating composition. When the acryl resin is included within the content range, the adhesion and the impact resistance of the coating film may be improved. In addition, when the content of the acryl resin is below the range, dryness is lowered to deteriorate the adhesive strength and the durability of the coating film, and when it is above the range, paint viscosity is increased to deteriorate painting workability, paint flowability, and water resistance.

[0031] First polyester resin

[0032] The first polyester resin serves to form the appearance characteristics and the mechanical properties of the coating film produced by a chemical bond with the isocyanate-based curing agent.

[0033] As the first polyester resin, a product which was directly synthesized according to a known method may be used or a commercially available product may be used. For example, the first polyester resin may be produced by reacting a first carboxylic acid and a first polyol.

[0034] Herein, the first carboxylic acid may be one or more

selected from the group consisting of adipic acid (AA), isophthalic acid (IPA), trimellitic anhydride (TMA), alicyclic acid, phthalic anhydride, isophthalic acid, terephthalic acid, succinic acid, adipic acid, fumaric acid, maleic anhydride, tetrahydrophthalic anhydride (HHPA), hexahydrophthalic anhydride, and derivatives thereof.

[0035] The first polyol may be, for example, one or more selected from the group consisting of methoxypolyethylene glycol, 1,6-hexanediol (1,6-HD), neopentylglycol (NPG), trimethylolpropane (TMP), ethylene glycol, propylene glycol, diethylene glycol, butanediol 1,4-hexanediol, and 3-methylenediol.

[0036] The first polyester resin may have a hydroxyl value (OHv) of 240 to 320 mg KOH/g or 260 to 290 mg KOH/g. When the first polyester resin has the hydroxyl value within the range, the spreadability of the coating film is improved and chemical resistance by a urethane reaction is improved. In addition, when the hydroxyl value of the first polyester resin is below the range, the crosslinking density with the isocyanate-based curing agent is insufficient to deteriorate the durability and the chemical resistance of the produced coating film, and when it is above the range, overcuring occurs so that the coating film becomes brittle and impact resistance and cold chipping resistance are deteriorated.

[0037] In addition, the first polyester resin may have a number average molecular weight (Mn) of 100 to 1,000 g/mol, 200 to 900 g/mol, or 300 to 800 g/mol. When the number average molecular weight of the first polyester resin is within the range, there is an effect of having smoothness of a paint and formation of a soft coating film. When the

number average molecular weight of the first polyester resin is below the range, the molecular weight is small so that the mechanical properties of the produced coating film is deteriorated, and when it is above the range, flowability is deteriorated by an increased molecular weight so that appearance is deteriorated and the coating film becomes brittle to deteriorate cold chipping resistance and impact resistance.

[0038] The first polyester resin may have an acid value (Av) of 5 to 35 mg KOH/g or 15 to 25 mg KOH/g. When the acid value of the first polyester resin is within the range, rapid curing by a heat treatment is prevented to prevent poor appearance of the coating film is prevented and occurrence of popping is decreased. When the acid value of the first polyester resin is below the range, a curing reaction rate is lowered to deteriorate the hardness and the appearance characteristics of the produced coating film, and when it is above the range, hydrophilicity is improved to deteriorate water resistance.

[0039] In addition, the first polyester resin may have a solid content (NV) of 50 to 80 wt% or 60 to 70 wt%. When the solid content of the first polyester resin is within the range, the content of the total volatile organic compound (TVOC) may be decreased by a high solid content. When the solid content of the first polyester resin is below the range, curing reactivity is lowered by the decreased solid content of the composition, and when it is above the range, the poor workability of the produced paint may occur to deteriorate appearance.

[0040] In addition, the first polyester resin may be

included at a content of 5 to 15 wt% or 8 to 12 wt%, based on the total weight of the coating composition. When the first polyester resin is included within the content range, appearance, scratch resistance, and coating film smoothness may be improved. When the content of the first polyester resin in the composition is below the range, crosslinking density is lowered to deteriorate mechanical properties and appearance, and when it is above the range, the viscosity of the composition may become excessively high to deteriorate workability and dryness.

[0041] The composition may include the first polyester resin and the second polyester resin at a weight ratio of 1.5:1 to 2.5:1 or 1.8:1 to 2.2:1. A mixing weight ratio of the first and the second polyester resin is within the range, the durability and the scratch resistance of the produced coating film are improved. When the mixing weight ratio of the first polyester resin and the second polyester resin is below the range, that is, the content of the first polyester resin is lower than the content of the second polyester resin, the crosslinking density of the produced coating film is lowered to deteriorate durability and scratch resistance, and when it is above the range, that is, the content of the first polyester resin is higher than the content of the second polyester resin, the viscosity of the composition is increased to deteriorate dryness and curing reactivity to deteriorate the mechanical properties of the produced coating film.

[0042] Second polyester resin

[0043] The second polyester resin serves to increase the solid content of the composition and improve the appearance,

the smoothness, the scratch resistance, and the slipperiness of the produced coating film.

[0044] As the second polyester resin, a product which was directly synthesized according to a known method may be used or a commercially available product may be used. For example, the second polyester resin may be produced by reacting a second carboxylic acid and a second polyol.

[0045] Herein, the second carboxylic acid may be one or more selected from the group consisting of adipic acid (AA), isophthalic acid (IPA), trimellitic anhydride (TMA), alicyclic acid, phthalic anhydride, isophthalic acid, terephthalic acid, succinic acid, adipic acid, fumaric acid, maleic anhydride, tetrahydrophthalic anhydride, hexahydrophthalic anhydride (HHPA), isononanoic acid (INA), and derivatives thereof.

[0046] The second polyol may be one or more selected from the group consisting of 1,6-hexanediol (1,6-HD), pentaerythritol, sorbitol, methoxypolyethylene glycol, neopentylglycol (NPG), trimethylolpropane (TMP), ethylene glycol, propylene glycol, diethylene glycol, butanediol 1,4-hexanediol, and 3-methylenediol.

[0047] The second polyester resin may have a hydroxyl value (OHv) of 100 to 180 mg KOH/g or 130 to 150 mg KOH/g. When the second polyester resin has the hydroxyl value within the range, the spreadability of the coating film is improved and chemical resistance by a urethane reaction is improved. In addition, when the hydroxyl value of the second polyester resin is below the range, the crosslinking density with the isocyanate-based curing agent is insufficient to deteriorate the appearance, the durability and the chemical resistance of

the produced coating film, and when it is above the range, overcuring occurs so that the coating film becomes brittle and painting workability and cold chipping resistance are deteriorated.

[0048] In addition, the second polyester resin may have a number average molecular weight (Mn) of 1,200 to 5,000 g/mol, 1,300 to 4,500 g/mol, or 1,500 to 4,000 g/mol. When the number average molecular weight of the second polyester resin is within the range, there is an effect of smoothness of a paint and formation of a soft coating film. When the number average molecular weight of the second polyester resin is below the range, the molecular weight is small so that the mechanical properties of the produced coating film is deteriorated, and when it is above the range, flowability is deteriorated by an increased molecular weight so that appearance is deteriorated and the coating film becomes hard to deteriorate cold chipping resistance.

[0049] In addition, the second polyester resin may have an acid value (Av) of 10 to 40 mg KOH/g or 20 to 30 mg KOH/g. When the acid value of the second polyester resin is within the range, rapid curing by a heat treatment is prevented, so that poor appearance of the coating film is prevented and occurrence of popping is decreased. When the acid value of the second polyester resin is below the range, a curing reaction rate is lowered to deteriorate the hardness and the appearance characteristics of the produced coating film, and when it is above the range, hydrophilicity is improved to deteriorate water resistance.

[0050] The second polyester resin may have a solid content (NV) of 60 to 80 wt% or 65 to 75 wt%. When the solid content

of the second polyester resin is within the range, the content of the total volatile organic compound (TVOC) may be decreased by a high solid content. When the solid content of the second polyester resin is below the range, the solid content of the composition is lowered to deteriorate curing reactivity to deteriorate the mechanical properties of the produced coating film, and when it is above the range, the workability of the produced paint becomes poor to deteriorate the appearance characteristics of the coating film.

[0051] In addition, the second polyester resin may be included at a content of 1 to 10 wt% or 3 to 7 wt%, based on the total weight of the coating composition. When the second polyester resin is included within the content range, appearance, scratch resistance, and coating film smoothness may be improved. When the content of the second polyester resin in the composition is below the range, the crosslinking density of the coating film is lowered to deteriorate cold chipping resistance and scratch resistance, and when it is above the range, the viscosity of the composition may become excessively high to deteriorate workability and dryness to deteriorate appearance.

[0052] Isocyanate-based curing agent

[0053] The isocyanate-based curing agent reacts with a hydroxyl group of the resin as described above to form a urethane bond to cure the composition, thereby forming a coating film.

[0054] The type of the isocyanate-based curing agent is not particularly limited, and for example, the isocyanate-based curing agent may include an aliphatic polyisocyanate compound having no yellowness. Specifically, the isocyanate-based

curing agent may include hexamethylene diisocyanate, isophorone diisocyanate, 4,4'-dicyclohexylmethane diisocyanate, tetramethyl xylene diisocyanate, or a mixture thereof.

[0055] In addition, the isocyanate-based curing agent may have a content (NCO%) of an unreacted isocyanate group of 15 to 30 wt% or 19 to 24 wt% with respect to the total weight of the curing agent. When the NCO% of the isocyanate-based curing agent is below the range, the crosslinking density of the coating film is lowered to deteriorate the impact resistance, the water resistance, and the cold chipping resistance of the coating film, and when it is above the range, a curing rate is increased and the resin aggregates to deteriorate the appearance characteristics, the gloss, and the mechanical properties of the coating film.

[0056] The isocyanate-based curing agent may be included in the composition at a content of 20 to 35 wt% or 24 to 29 wt%, based on the total weight of the coating composition. When the content of the isocyanate-based curing agent is below the range, the reactivity of the composition is insufficient to deteriorate the crosslinking density to deteriorate mechanical properties, and when it is above the range, an unreacted isocyanate group occurs in the coating film after curing to deteriorate the appearance and the workability of the coating film.

[0057] The clear coating composition may further include a solvent.

[0058] Solvent

[0059] The solvent serves to adjust the viscosity of the composition, improve dryness, and improve the appearance

characteristics and the spreadability of the produced coating film.

[0060] The solvent is not particularly limited as long as it is commonly used in the clear coating composition, and for example, may include one or more selected from the group consisting of aromatic, acetate-based, alcohol-based, and propionate-based solvents. Specifically, the solvent may include aromatic solvents such as toluene and xylene; acetate-based solvents such as 1-methoxy-2-propylacetate, methyl acetate, ethyl acetate, n-propyl acetate, n-butyl acetate, methyl glutarate, methyl succinate, methyl adipate, dimethyl glutarate, dimethyl succinate, dimethyl adipate, propylene glycol methyl ether acetate (PMA), butyl carbitol acetate, and butyl cellosolve acetate; alcohol-based solvents such as n-butanol, propanol, 1-methoxy-2-propanol, and 2-butoxyethanol; ketone-based solvents such as acetone, methylethylketone, methyl butyl ketone, and methyl isobutyl ketone; propionate-based solvents such as ethyl ethoxypropionate, and the like. In addition, the commercial product of the aromatic solvent may include Kocosol #100, Kocosol #150, and the like.

[0061] In addition, the solvent may be included in the composition at a content of 15 to 45 wt% or 25 to 35 wt%, based on the total weight of the coating composition. When the solvent is included within the range, the viscosity of the composition is appropriately adjusted to improve workability and dryness.

[0062] Additive

[0063] The clear coating composition according to the present invention may further include an additive such as a

curing catalyst, a UV absorber, a surface smoothing agent, and a flowability adjusting agent. Herein, the additive is not particularly limited as long as it is commonly added to the coating composition.

[0064] In addition, the content of the additive is not particularly limited as long as it is commonly included in the clear coating composition. For example, the additive may be included in the coating composition at a content of 1 to 10 wt% or 3 to 7 wt%, based on the total weight of the coating composition.

[0065] Two-pack type coating composition

[0066] The clear coating composition may be a two-pack type coating composition including a main part and a curing agent part. For example, the clear coating composition may include the main part including the acryl resin, the first polyester resin, the second polyester resin, the solvent, and the additive; and the curing agent part including the isocyanate-based curing agent. In addition, the clear coating composition may be used after mixing the main part and the curing agent part before application.

[0067] The clear coating composition may have a solid content of 40 to 60 wt% or 45 to 55 wt%. When the solid content of the clear coating composition is within the range, the painting workability of the composition may become appropriate.

[0068] The clear coating composition may be cured at 60°C to 120°C, 70°C to 110°C, or 80°C to 110°C. Since the clear coating composition is curable within the temperature range, costs required for a painting process may be reduced, and thus, it is economical, and since it may paint a car body and

material parts attached thereto integrally, it may prevent a problem of having different colors between the parts and the car body after painting. In addition, since it may paint both a car body and parts with one painting process, inconvenience in the process and cost loss may be reduced.

[0069] The clear coating composition may have a viscosity of 40 to 70 seconds or 50 to 60 seconds, based on Ford Cup No. 4 at 25°C. When the viscosity of the clear coating composition at 25°C is below the range, a problem such as flowing down on a vertical plane may occur, and when it is above the range, the viscosity of the composition is so high that the appearance characteristics of the coating film produced therefrom is deteriorated or a load is applied to a coater to cause coater failure.

[0070] Since the clear coating composition according to the present invention as described above is curable at a low temperature at 120°C or lower and may reduce costs of a painting process, it is economical, and since it may paint a car body and material parts attached thereto integrally, it may prevent a problem of having different colors between the parts and the car body after painting. In addition, since it may paint both a car body and parts with one painting process, inconvenience in the process and cost loss may be reduced. Furthermore, since a coating film produced from the clear coating composition has excellent mechanical properties such as hardness, adhesion, water resistance, acid resistance, scratch resistance, and solvent resistance, it may be useful for car body painting.

BEST MODE FOR CARRYING OUT THE INVENTION

[0071] Hereinafter, the present invention will be described

in more detail through the following examples. However, the following examples are only to assist in the understanding of the present invention, and the scope of the present invention is not limited thereto in any sense.

[0072] Examples 1 to 15 and Comparative Examples 1 to 7: Preparation of clear coating composition

[0073] The components were mixed at the contents in Tables 1 to 3 to prepare clear coating compositions having a viscosity at 25°C of 55 seconds, based on Ford Cup No. 4.

[0074] [Table 1]

Component (wt%)	Example						
	1	2	3	4	5	6	7
Acryl resin	25	25	25	25	25	25	25
First polyester resin-1	9.8	-	-	9.8	9.8	8	12
First polyester resin-2	-	9.8	-	-	-	-	-
First polyester resin-3	-	-	9.8	-	-	-	-
First polyester resin-4	-	-	-	-	-	-	-
First polyester resin-5	-	-	-	-	-	-	-
Second polyester resin-1	4.8	4.8	4.8	-	-	4.8	4.8
Second polyester resin-2	-	-	-	4.8	-	-	-
Second polyester resin-3	-	-	-	-	4.8	-	-
Second polyester resin-4	-	-	-	-	-	-	-
Second polyester resin-5	-	-	-	-	-	-	-
Isocyanate-based curing agent	26	26	26	26	26	26	26
Curing catalyst	0.1	0.1	0.1	0.1	0.1	0.1	0.1
UV absorber	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Surface smoothing agent	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Flowability adjusting agent	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Solvent	29.3	29.3	29.3	29.3	29.3	31.1	27.1
Total	100	100	100	100	100	100	100

[0075] [Table 2]

Component (wt%)	Example							
	8	9	10	11	12	13	14	15
Acryl resin	25	25	25	25	17	33	12	38
First polyester resin-1	6	13	3	18	9.8	9.8	9.8	9.8
First polyester resin-2	-	-	-	-	-	-	-	-
First polyester resin-3	-	-	-	-	-	-	-	-
First polyester resin-	-	-	-	-	-	-	-	-

4								
First polyester resin-5	-	-	-	-	-	-	-	-
Second polyester resin-1	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
Second polyester resin-2	-	-	-	-	-	-	-	-
Second polyester resin-3	-	-	-	-	-	-	-	-
Second polyester resin-4	-	-	-	-	-	-	-	-
Second polyester resin-5	-	-	-	-	-	-	-	-
Isocyanate-based curing agent	26	26	26	26	26	26	26	26
Curing catalyst	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
UV absorber	1.6	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Surface smoothing agent	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Flowability adjusting agent	2.9	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Solvent	33.1	26.1	36.1	21.1	37.3	21.3	42.3	16.3
Total	100	100	100	100	100	100	100	100

[0076] [Table 3]

Component (wt%)	Comparative Example						
	1	2	3	4	5	6	7
Acryl resin	25	25	25	25	-	25	25
First polyester resin-1	-	-	9.8	9.8	15	-	9.8
First polyester resin-2	-	-	-	-	-	-	-
First polyester resin-3	-	-	-	-	-	-	-
First polyester resin-4	9.8	-	-	-	-	-	-
First polyester resin-5	-	9.8	-	-	-	-	-
Second polyester resin-1	4.8	4.8	-	-	7	4.8	-
Second polyester resin-2	-	-	-	-	-	-	-
Second polyester resin-3	-	-	-	-	-	-	-
Second polyester resin-4	-	-	4.8	-	-	-	-
Second polyester resin-5	-	-	-	4.8	-	-	-
Isocyanate-based curing agent	26	26	26	26	29	26	26
Curing catalyst	0.1	0.1	0.1	0.1	0.1	0.1	0.1
UV absorber	1.6	1.6	1.6	1.6	1.6	1.6	1.6
Surface smoothing agent	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Flowability adjusting agent	2.9	2.9	2.9	2.9	2.9	2.9	2.9
Solvent	29.3	29.3	29.3	29.3	43.9	39.1	34.1
Total	100	100	100	100	100	100	100

[0077] Hereinafter, the manufacturers, the product names, the component names, or the like used in the comparative

examples and the examples are shown in Table 4.

[0078] [Table 4]

Component	Manufacturer, product name, physical properties, or compound name
Acryl resin	Mw: 25,000 g/mol, OHv: 155 mg KOH/g, Av: 9 mg KOH/g, Tg: 56°C, NV: 70 wt%
First polyester resin-1	Mn: 500 g/mol, OHv: 275 mg KOH/g, Av: 20 mg KOH/g, NV: 65 wt%
First polyester resin-2	Mn: 500 g/mol, OHv: 250 mg KOH/g, Av: 20 mg KOH/g, NV: 65 wt%
First polyester resin-3	Mn: 500 g/mol, OHv: 310 mg KOH/g, Av: 20 mg KOH/g, NV: 65 wt%
First polyester resin-4	Mn: 500 g/mol, OHv: 228 mg KOH/g, Av: 20 mg KOH/g, NV: 65 wt%
First polyester resin-5	Mn: 500 g/mol, OHv: 330 mg KOH/g, Av: 20 mg KOH/g, NV: 65 wt%
Second polyester resin-1	Mn: 1,950 g/mol, OHv: 135 mg KOH/g, Av: 25 mg KOH/g, NV: 69 wt%
Second polyester resin-2	Mn: 1,950 g/mol, OHv: 115 mg KOH/g, Av: 25 mg KOH/g, NV: 69 wt%
Second polyester resin-3	Mn: 1,950 g/mol, OHv: 170 mg KOH/g, Av: 25 mg KOH/g, NV: 69 wt%
Second polyester resin-4	Mn: 1,950 g/mol, OHv: 91 mg KOH/g, Av: 25 mg KOH/g, NV: 69 wt%
Second polyester resin-5	Mn: 1,950 g/mol, OHv: 187 mg KOH/g, Av: 25 mg KOH/g, NV: 69 wt%
Isocyanate-based curing agent	NCO content: 22 wt%
Curing catalyst	Dibutyltin dilaurate
UV absorber	Manufacturer: BASF, product name: Tinuvin 384
Surface smoothing agent	Manufacturer: BASF, product name: BYK-325
Flowability adjusting agent	Manufacturer: Akzo Nobel, product name: Setalux 81198 SS-55
Solvent	mixed and used at a weight ratio of Kocosol #100, xylene, and butyl acetate of 1:1:1

[0079] Experimental Example: Evaluation of characteristics of coating film

[0080] A top coat paint (manufacturer: KCC, product name: WT3090) was applied on a specimen and dried to form a top coat coating film having a thickness of 15 μm. Thereafter, the clear coating compositions produced in the examples and the comparative examples were painted on the top coat coating film, and cured at 100°C for 25 minutes to form a clear

coating film having a thickness of 40 μm to produce a final coating film. The physical properties of the specimen were measured, and the results are shown in Table 5.

[0081] Specifically, the clear coating film was painted using a hand gun spray (nozzle caliber: 1.5 mm, air pressure: maintained constant around 4.5 kgf/cm^2), while maintaining a distance between a nozzle opening and the specimen constant at 30 cm and moving horizontally at a speed of 40-50 cm/sec.

[0082] (1) Painting workability

[0083] When the paint was discharged with the hand gun spray, the clear coating composition of the examples and the comparative examples were reciprocatingly painted twice and the atomization degree, the smoothness level, and the high build coating ability of the paint during painting were compared.

[0084] Specifically, the painting workability was evaluated as excellent (◎) when visually, paint spreadability on the surface was good and a high build coating ability was excellent, evaluated as good (○) when visually, a high build coating ability was good, but paint spreadability was insufficient, evaluated as normal (△) when visually, a high build coating ability and paint spreadability were insufficient and less than 3 paint foreign matters occurred, and evaluated as poor (×) when 3 or more paint foreign matters occurred and cratering occurred.

[0085] (2) Appearance

[0086] Gloss (LU), sharpness (SH), and orange peel (OP) of the produced final coating film were measured using Wave Scan DOI (BYK Gardner) which is a car exterior meter, and a comprehensive appearance evaluation value (CF) was calculated

by the following Equation 1, using the measured physical properties.

[0087] [Mathematical Formula 1]

[0088] $CF = LU \times 0.15 + SH \times 0.35 + OP \times 0.5$

[0089] At this time, CF was measured and calculated horizontally and vertically.

[0090] The appearance was evaluated as excellent (◎) when the calculated CF was 65 or more, evaluated as good (○) when CF was 60 or more and less than 65, evaluated as normal (△) when CF was 55 or more and less than 60, and evaluated as poor (×) when CF was less than 55.

[0091] (3) Gloss

[0092] The 20° gloss of the painted specimen was measured using a gloss meter, and the 20° gloss of 90 or more was evaluated as excellent (◎), the 20° gloss of 85 or more and less than 90 was evaluated as good (○), the 20° gloss of 80 or more and less than 85 was evaluated as normal (△), and the 20° gloss of less than 80 was evaluated as poor (×).

[0093] (4) Repainting adhesion

[0094] The top coat coating film and the clear coating film were all removed, the top coat paint and the clear coating composition were painted in the same manner as described above, and repainting adhesion was evaluated by a checkerboard method.

[0095] Specifically, in the checkerboard method, the surface of the clear coating film was cut into 100 squares of 2 mm wide by 2 mm high with a knife and the squares were detached using a tape to measure adhesion. At this time, the measured adhesion was evaluated as excellent (◎) when 100% of 100 squares were completely attached, evaluated as good (○) when

70% or more and less than 100% of the squares remained, evaluated as normal (△) when 50% or more and less than 70% of the squares remained, and evaluated as poor (×) when less than 50% of the squares remained.

[0096] (5) Impact resistance

[0097] The impact resistance of the painted specimen was evaluated in accordance with ASTM D2794. At this time, a DuPont impact tester was used, and when a weight of 500g was dropped on the specimen while the drop height of the weight was changed from 30 cm to 50 cm, the appearance of the coating film was observed. As a result of observation, the impact resistance was evaluated excellent (◎) when cracks and delamination did not occur on the top coat coating film at a drop height of the weight of 50 cm, evaluated as good (○) when the drop height was 40 cm or more and less than 50 cm, evaluated as normal (△) when the drop height was 30 cm or more and less than 40 cm, and evaluated as poor (×) when the drop height was less than 30 cm.

[0098] (6) Water resistance

[0099] The final coating film was dipped in a constant temperature water tank at 40°C for 240 hours, allowed to stand at room temperature for 1 hour, and then evaluated for adhesion in the same manner as in the checkerboard method of item (4), and the evaluation criteria were identically applied.

[00100] (7) Paint flowability

[00101] A specimen in which a top coat coating film was formed on a steel plate with a hole having a diameter of 5 mm was hung vertically, the clear coating compositions of the examples and the comparative examples were painted in the

same manner as described above, and dried and cured, and the surface of the produced coating film was observed to evaluate the paint flowability of the composition.

[00102] Specifically, a paint form in a lower portion of the hole was observed, and a thickness of the coating film at a starting point where flow occurrence was observed was recorded as a flow limit film thickness. At this time, as the value of the measured flow limit film thickness was lower, it was considered that paint flowability was insufficient. At this time, the paint flowability was evaluated as excellent (◎) when the flow limit film thickness was 40 μm or more was, evaluated as good (○) when the flow limit film thickness was 35 μm or more and less than 40 μm, evaluated as normal (△) when the flow limit film thickness was 30 μm or more and less than 35 μm, and evaluated as poor (×) when the flow limit film thickness was less than 30 μm.

[00103] (8) Cold chipping resistance

[00104] A painted specimen having a size of 150 mm×70 mm was allowed to stand at -20±3°C for 3 hours, and cold chipping resistance was measured using a chipping resistance tester (manufacturer: Gravelometer, model name: SAE J 400). Specifically, 50 g of chipping stones (diameter: 4 mm) was sprayed on a final paint with a pressure of 4 bar at an angle of 45°C. Thereafter, the specimen was taken out and foreign matter such as a delaminated coating film remaining in the coating film was removed with a cellophane adhesive tape.

[00105] At this time, the cold chipping resistance was evaluated as excellent (◎) when the damaged area of the final coating film was 1 mm or less, evaluated as good (○) when the damaged area was more than 1 mm and 2 mm or less,

evaluated as normal (△) when the damaged area was more than 2 mm and 3 mm or less, and evaluated as poor (×) when the damaged area was more than 3 mm.

[00106] [Table 5]

		Painting workability	Appearance	Gloss	Repainting adhesion	Impact resistance	Water resistance	Paint flowability	Cold chipping resistance
Example	1	◎	◎	◎	◎	◎	◎	◎	◎
	2	◎	◎	◎	◎	○	○	◎	○
	3	◎	○	○	◎	○	◎	◎	○
	4	◎	○	◎	◎	○	○	◎	○
	5	○	○	○	◎	◎	◎	◎	○
	6	◎	◎	◎	◎	◎	◎	◎	◎
	7	◎	◎	◎	◎	◎	◎	◎	◎
	8	◎	○	◎	◎	○	○	◎	○
	9	○	○	○	◎	◎	◎	○	◎
	10	◎	△	○	◎	△	△	◎	△
	11	△	△	△	○	◎	◎	△	◎
	12	◎	○	◎	○	○	○	◎	○
	13	○	◎	◎	◎	◎	○	○	◎
	14	◎	△	◎	△	△	△	◎	△
	15	△	○	○	◎	◎	△	△	◎
Comparative Example	1	◎	○	○	◎	X	X	◎	X
	2	◎	X	X	○	X	○	○	X
	3	◎	X	◎	◎	X	X	◎	X
	4	X	X	X	◎	○	◎	○	X
	5	△	X	△	X	X	X	○	X
	6	○	X	△	○	X	○	X	X
	7	○	△	X	○	X	X	△	X

[00107] As seen in Table 5, the compositions of the examples had better painting workability and paint flowability than the compositions of the comparative examples, and the coating films produced from the compositions of the examples had appearance, gloss, repainting adhesion, impact resistance, and cold chipping resistance which were better than those of the coating films of the comparative examples.

[00108] Meanwhile, the coating film of Comparative Example 1

including the first polyester resin-4 having a low hydroxyl value and the coating film of Comparative Example 3 including the second polyester resin-4 having a low hydroxyl value had insufficient impact resistance, water resistance, and cold chipping resistance. In particular, the coating film of Comparative Example 3 had insufficient appearance characteristics.

[00109] In addition, the coating film of Comparative Example 2 including the first polyester resin-5 having a high hydroxyl value and the coating film of Comparative Example 4 including the second polyester resin-5 having a high hydroxyl value had insufficient appearance characteristics, gloss, and cold chipping resistance. In particular, the coating film of Comparative Example 2 also had insufficient impact resistance, and the composition of Comparative Example 4 had insufficient painting workability.

[00110] The coating film of Comparative Example 5 including no acryl resin had appearance characteristics, repainting adhesion, impact resistance, water resistance, and cold chipping resistance which were insufficient.

[00111] In addition, the composition of Comparative Example 5 including only one second polyester resin without the first polyester resin had insufficient paint flowability and the coating film produced therefrom had insufficient appearance characteristics, impact resistance, and cold chipping resistance.

[00112] The coating film of Comparative Example 7 including only one first polyester resin without the second polyester resin had insufficient gloss, impact resistance, water resistance, and cold chipping resistance.

CLAIMS

1. A low-temperature curable clear coating composition comprising: an acryl resin, a first polyester resin, a second polyester resin, and an isocyanate-based curing agent,

wherein the acryl resin has a weight average molecular weight of 10,000 to 40,000 g/mol, a hydroxyl value of 100 to 200 mg KOH/g, an acid value of 5 to 15 mg KOH/g, and a glass transition temperature of 20 to 100°C,

wherein the first polyester resin has an acid value of 5 to 35 mg KOH/g, a hydroxyl value of 260 to 290 mg KOH/g and a number average molecular weight of 300 to 800 g/mol,

the second polyester resin has an acid value of 10 to 40 mg KOH/g, a hydroxyl value of 130 to 150 mg KOH/g and a number average molecular weight of 1,500 to 4,000 g/mol,

wherein the first polyester resin and the second polyester resin are included at a weight ratio of 1.5:1 to 2.5:1,

wherein the isocyanate-based curing agent has a content of an unreacted isocyanate group of 15 to 30 wt%, with respect to the total weight of the curing agent, and

wherein 15 to 35 wt% of the acryl resin, 5 to 15 wt% of the first polyester resin, 1 to 10 wt% of the second polyester resin, and 20 to 35 wt% of the isocyanate-based curing agent are included, based on the total weight of the coating composition.