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(54) **PIGMENT DISPERSANT, METHOD OF
MAKING COATING COMPOSITIONS, AND
COATING COMPOSITIONS**

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(57) **ABSTRACT**

A coating composition comprises at least one pigment dispersed in an acrylic polymer, wherein the acrylic polymer is polymerized from a mixture of ethylenically unsaturated monomers comprising: (a) one or more monomers having active hydrogen functionality; (b) at least about 5% by weight of one or more monomers selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene(meth)acrylates, ω -methyloxy-poly(oxyethylene-co-oxypropylene)(meth)acrylates, and combinations thereof; (c) optionally hydroxyethylene ethyl urea (meth)acrylate; and (d) up to about 50 percent by weight of one or more monomers selected from the group consisting of aromatic polymerizable monomers, wherein the monomers (b) and (c) combined are from about 5 to about 45 percent by weight of the mixture of ethylenically unsaturated monomers.

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PIGMENT DISPERSANT, METHOD OF MAKING COATING COMPOSITIONS, AND COATING COMPOSITIONS

FIELD OF THE INVENTION

[0001] The invention relates pigment dispersants and methods of making coating compositions with pigment dispersants.

BACKGROUND OF THE INVENTION

[0002] Coating finishes, particularly exterior coating finishes in the automotive industry, are generally applied in two or more distinct layers. One or more layers of primer coating composition may be applied to the unpainted substrate first, followed by one or more topcoat layers. Basecoat-clearcoat composite coatings are particularly useful as topcoats for which exceptional gloss, depth of color, distinctness of image, or special metallic effects are desired. The basecoat layer contains the colorants that provide the color for the topcoat, while the clearcoat layer provides a smooth, glossy finish. The automotive industry has made extensive use of these coatings for automotive body panels.

[0003] The colorants in automotive basecoat compositions are typically one or more dispersed pigments. Pigment dispersion in the composition must accomplish at least two objectives. First, the pigment should be as fully wet-out as possible for optimum color development in the coating layer. Secondly, the pigment should be stabilized against hard settling and re-agglomeration of the pigment particles so that the basecoat composition will have a reasonably long shelf-life. Many types of dispersants have been suggested for solventborne compositions. The options for waterborne compositions has been more limited, as the dispersant must itself be water-dispersible. Nonetheless, waterborne basecoat compositions are in need of the same good color development and stability as solventborne basecoat compositions. A pigment dispersant useful in both solventborne and waterborne compositions would simplify manufacturing and storage because the same dispersant intermediate could be synthesized and used to made pigment dispersions for either solventborne or waterborne compositions.

SUMMARY OF THE INVENTION

[0004] The present invention provides pigment dispersions offering excellent color development in coating compositions, particularly for basecoat coating compositions.

[0005] A pigmented coating composition of the invention comprises at least one pigment dispersed in an acrylic polymer, wherein the acrylic polymer is polymerized from a mixture of ethylenically unsaturated monomers comprising: (a) one or more monomers having active hydrogen functionality; (b) at least about 5% by weight of one or more monomers selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene (meth)acrylates, ω -methyloxy-poly(oxyethylene-co-oxypropylene) (meth)acrylates, and combinations thereof; (c) optionally hydroxyethylene ethyl urea (meth)acrylate; and (d) up to about 50 percent by weight of one or more monomers selected from the group consisting of aromatic polymerizable monomers, wherein the monomers (b) and (c)

combined are from about 5 to about 45 percent by weight of the mixture of ethylenically unsaturated monomers. The composition may be solventborne or waterborne.

[0006] A waterborne basecoat composition of the invention comprises an aqueous dispersion having at least one pigment dispersed by an acrylic polymer, wherein the acrylic polymer is polymerized from a mixture of ethylenically unsaturated monomers comprising: (a) one or more monomers having active hydrogen functionality; (b) at least about 5% by weight of one or more monomers selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene (meth)acrylates, and combinations thereof; (c) optionally hydroxyethylene ethyl urea (meth)acrylate; and (d) up to about 50 percent by weight of one or more monomers selected from the group consisting of aromatic polymerizable monomers, wherein the monomers (b) and (c) combined are from about 5 to about 45 percent by weight of the mixture of ethylenically unsaturated monomers. Preferably, the waterborne basecoat composition also comprises a film-forming polymer other than the acrylic polymer dispersing the pigment, and preferably a crosslinking agent.

[0007] The coating compositions of the invention exhibit excellent color development, humidity resistance, and adhesion.

[0008] As used herein, "(meth)acrylate" refers to both the acrylate and methacrylate compound. "A" and "an" as used herein indicate "at least one" of the item is present; a plurality of such items may be present, when possible. "About" when applied to values indicates that the calculation or the measurement allows some slight imprecision in the value (with some approach to exactness in the value; approximately or reasonably close to the value; nearly). If, for some reason, the imprecision provided by "about" is not otherwise understood in the art with this ordinary meaning, then "about" as used herein indicates a possible variation of up to 5% in the value.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0009] The following description of the preferred embodiment(s) is merely exemplary in nature and is in no way intended to limit the invention, its application, or uses.

[0010] The coating composition includes at least one pigment dispersed in an acrylic polymer. The acrylic polymer is polymerized from a mixture of ethylenically unsaturated monomers comprising: (a) one or more monomers having active hydrogen functionality; (b) at least about 5% by weight of one or more monomers selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene (meth)acrylates, ω -methyloxy-poly(oxyethylene-co-oxypropylene) (meth)acrylates, and combinations thereof; (c) optionally hydroxyethylene ethyl urea (meth)acrylate; and (d) up to about 50 percent by weight of one or more monomers selected from the group consisting of aromatic polymerizable monomers, wherein the monomers (b) and (c) combined are from about 5 to about 45 percent by weight of the mixture of ethylenically unsaturated monomers

[0011] Suitable examples of ethylenically unsaturated monomers having active hydrogen functionality (a) include, without limitation, acrylamide, methacrylamide, beta-hydroxyalkyl carbamate (meth)acrylates such as beta-hydroxypropyl carbamate methacrylate, carbamate alkyl-(meth)acrylates, carbamoyloxyalkyl(meth)acrylates such as 2-carbamoyloxyethyl methacrylate and 4-carbamoyloxybutyl acrylate, beta- and gamma-carbamoyloxyhydroxyalkyl-(meth)acrylates such as 2-carbamoyloxy-3-hydroxypropyl methacrylate and 3-carbamoyloxy-2-hydroxypropyl methacrylate, hydroxyalkyl(meth)acrylates such as hydroxyethyl (meth)acrylate, hydroxypropyl(meth)acrylate, hydroxybutyl(meth)acrylate, esters of epsilon caprolactone and hydroxyalkyl(meth)acrylates such as the commercially available Tone 100M monomer (from Dow Chemical), mono(meth)acrylates of polyethylene glycols, and combinations of these. Hydroxyl and carbamate functionalities are preferred. The acrylic polymer preferably has an active hydrogen group equivalent weight of from about 400 to about 2000, more preferably from about 400 to about 1000.

[0012] The dispersant acrylic polymer also includes at least about 5% by weight of one or more polymerized monomers (b) selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene (meth)acrylates, ω -methyloxy-poly(oxyethylene-co-oxypropylene) (meth)acrylates, and combinations of these. Preferred examples of ethylenically unsaturated monomer having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms are oligomers of (meth)acrylic acid, particularly β -carboxyethyl acrylate. Other examples of ethylenically unsaturated monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms are the reaction products of hydroxyalkyl (meth)acrylates (e.g., hydroxyethyl methacrylate, hydroxypropyl acrylate) with cyclic carboxylic acid anhydrides (e.g., succinic anhydride, isophthalic anhydride), such as monomethacryloyloxyethyl hexahydrophthalate. Preferred examples of ω -methyloxy-polyoxyethylene (meth)acrylates and ω -methyloxy-poly(oxyethylene-co-oxypropylene) (meth)acrylates are those having molecular weights of at least about 750, more preferably at least about 1000, and those having molecular weights of up to about 4500, more preferably up to about 3000, and still more preferably up to about 2500. Particularly preferred, especially for waterborne compositions, are ω -methyloxy-polyoxyethylene (meth)acrylates of those molecular weights. The mixture of ethylenically unsaturated monomer used to prepare the dispersing acrylic polymer preferably includes one or more monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms in an amount sufficient so that the acrylic polymer has an acid equivalent weight of 800 or more grams per equivalent, more preferably an equivalent weight of about 2000 or less and from about 1000 or more grams per equivalent. The mixture of ethylenically unsaturated monomer used to prepare the dispersing acrylic polymer preferably includes up to about 20 percent by weight of one or more ω -methyloxy-polyoxyethylene (meth)acrylates, more preferably up to about 15% by weight of one or more ω -methyloxy-polyoxyethylene

(meth)acrylates, and also preferably at least about 5% by weight of the one or more ω -methyloxy-polyoxyethylene (meth)acrylates.

[0013] Optionally, the mixture of ethylenically unsaturated monomers used to prepare the dispersing acrylic polymer includes (c) hydroxyethylene ethyl urea methacrylate and/or hydroxyethylene ethyl urea acrylate. The mixture of ethylenically unsaturated monomer used to prepare the dispersing acrylic polymer includes preferably up to about 10 percent by weight, more preferably up to about 7% by weight hydroxyethylene ethyl urea (meth)acrylate, and also preferably includes at least about 1% by weight, more preferably at least about 2% by weight, and still more preferably at least about 3% by weight hydroxyethylene ethyl urea (meth)acrylate.

[0014] Together the monomers (b) selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene(meth)acrylates, ω -methyloxy-poly(oxyethylene-co-oxypropylene) (meth)acrylates, and combinations of these and the monomer (c) hydroxyethylene ethyl urea (meth)acrylate comprise at least about 5 weight percent, more preferably at least about 15 weight percent of the mixture of ethylenically unsaturated monomers polymerized to form the acrylic polymer. It is also preferred that together the monomers (b) selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene(meth)acrylates, ω -methyloxy-poly(oxyethylene-co-oxypropylene)(meth)acrylates, and combinations of these and the monomer (c) hydroxyethylene ethyl urea (meth)acrylate comprise up to about 45 weight percent, more preferably up to about 35 weight percent of the mixture of ethylenically unsaturated monomers polymerized to form the acrylic polymer.

[0015] The mixture of ethylenically unsaturated monomers polymerized to form the acrylic polymer preferably includes one or more aromatic polymerizable monomers. Suitable examples of aromatic polymerizable monomers include, without limitation, styrene, α -methyl styrene, vinyl toluene, tert-butyl styrene, and combinations of these. The mixture of ethylenically unsaturated monomer used to prepare the dispersing acrylic polymer preferably includes at least about 5 percent, more preferably at least about 15 percent by weight of one or more aromatic polymerizable monomers. The mixture of ethylenically unsaturated monomer used to prepare the dispersing acrylic polymer includes up to about 50 percent, preferably up to about 30 percent, and more preferably up to about 25 percent by weight of one or more aromatic polymerizable monomers.

[0016] The mixture of ethylenically unsaturated monomers may include other polymerizable monomers, such as, for example and without limitation, esters of α,β -ethylenically unsaturated monocarboxylic acids containing 3 to 5 carbon atoms such as acrylic, methacrylic, and crotonic acids; mono- and di-esters of α,β -ethylenically unsaturated dicarboxylic acids containing 4 to 6 carbon atoms; vinyl esters, vinyl ethers, vinyl ketones, and heterocyclic aliphatic vinyl compounds. Representative examples of suitable esters of acrylic, methacrylic, and crotonic acids include,

without limitation, those esters from reaction with saturated aliphatic alcohols containing 1 to 20 carbon atoms, such as methyl, ethyl, propyl, isopropyl, n-butyl, isobutyl, tert-butyl, hexyl, 2-ethylhexyl, dodecyl, cyclohexyl, alkyl-substituted cyclohexyl, alkanol-substituted cyclohexyl, such as 2-tert-butyl and 4-tert-butyl cyclohexyl, 4-cyclohexyl-1-butyl, and 3,3,5,5-tetramethyl cyclohexyl; isobornyl, lauryl, and stearyl acrylates, methacrylates, and crotonates. Representative examples of other ethylenically unsaturated polymerizable monomers include, without limitation, such compounds as fumaric, maleic, and itaconic monoesters, and diesters with alcohols such as methanol, ethanol, propanol, isopropanol, butanol, isobutanol, and tert-butanol. Representative examples of co-polymerizable vinyl monomers include, without limitation, such compounds as vinyl acetate, vinyl propionate, vinyl ethers such as vinyl ethyl ether, vinyl and vinylidene halides, vinyl ethyl ketone, and 2-vinyl pyrrolidone.

[0017] The acrylic polymer is prepared according to usual methods, such as by bulk or solution polymerization. The acrylic polymer preferably has a weight average molecular weight of from about 8,000 to about 70,000.

[0018] After polymerization, any acid functionality may be salted, preferably with an alkali or base, preferably an amine, even more preferably a tertiary amine. Examples of suitable salting materials include, without limitation, ammonia, monoethanolamine, ethylamine, dimethylamine, diethylamine, triethylamine, propylamine, dipropylamine, isopropylamine, diisopropylamine, triethanolamine, butylamine, dibutylamine, 2-ethylhexylamine, ethylenediamine propylenediamine, ethylethanolamine, dimethylethanolamine, diethylethanolamine, 2-amino-2-methylpropanol, and morpholine. Preferred salting materials include 2-amino-2-methylpropanol and dimethylethanolamine.

[0019] The acrylic polymers may be prepared as solutions in an organic solvent medium. For aqueous coating compositions, the organic solvent or solvents are preferably selected from water-soluble or water-miscible organic solvents, and after polymerization the acrylic polymers are dispersed into water. After dispersion into water, the organic solvent can be distilled from the aqueous dispersion or emulsion.

[0020] The acrylic polymers may also be prepared by emulsion polymerization. Preferably, a nonionic or an anionic surfactant is used for the emulsion polymerization. Suitable surfactants include, without limitation, polyoxyethylenenonylphenyl ethers, polyoxyethylenealkylallyl ether sulfuric acid esters, amino and alkali salts of dodecylbenzenesulfonic acid such as the dimethylethanolamine salt of dodecylbenzenesulfonic acid and sodium dodecylbenzenesulfonic acid, and sodium dioctylsulfosuccinate.

[0021] The polymerization may be carried out by free radical polymerization. The free radical source is typically supplied by a redox initiator or by an organic peroxide or azo compound. Useful initiators include, without limitation, ammonium peroxydisulfate, potassium peroxydisulfate, sodium metabisulfite, hydrogen peroxide, t-butyl hydroperoxide, dilauryl peroxide, t-butyl peroxybenzoate, 2,2'-azobis(isobutyronitrile), and redox initiators such as ammonium peroxydisulfate and sodium metabisulfite with ferrous ammonium sulfate. Optionally, a chain transfer agent may be used. Typical chain transfer agents include mercaptans

such as octyl mercaptan, n- or tert-dodecyl mercaptan, thiosalicylic acid, mercaptoacetic acid, and mercaptoethanol; halogenated compounds; and dimeric alpha-methyl styrene.

[0022] The coating compositions according to the invention further include a pigment that may be selected from any organic or inorganic compounds or colored materials. Examples of suitable classes of organic pigments that may be used include, without limitation, metallized and non-metallized azo pigments, azomethine pigments, methine pigments, anthraquinone pigments, phthalocyanine pigments, perinone pigments, perylene pigments, diketopyrrolopyrrole pigments, thioindigo pigments, iminoisoindoline pigments, iminoisoindolinone pigments, quinacridone pigments such as quinacridone reds and violets, flavanthrone pigments, indanthrone pigments, anthrapyrimidine pigments, carbazole pigments, monoarylide and diarylide yellows, benzimidazolone yellows, tolyl orange, naphthol orange, and quinophthalone pigments. Examples of suitable inorganic pigments include, without limitation, metal oxide pigments such as titanium dioxide, iron oxides including red iron oxide, black iron oxide, and brown iron oxide, and chromium oxide green; carbon black; ferric ferrocyanide (Prussian blue); ultramarine; lead chromate; and so on.

[0023] The color pigment or pigments are dispersed in the acrylic polymer according to known methods. In general, dry pigment and the acrylic polymer are brought into contact under a shear high enough to break the pigment agglomerates down to the primary pigment particles and to wet the surface of the pigment particles. The breaking of the agglomerates and wetting of the primary pigment particles are important for pigment stability and color development. All of the pigments may be dispersed together in the acrylic polymer or separate pigment dispersions may be made for one or more pigments that are then combined in the coating composition.

[0024] The coating composition may also include fillers and/or metallic or other inorganic flake materials such as pearlescent mica flake pigments or metallic flake pigments such as aluminum flake. Metallic basecoat colors are produced using one or more special flake pigments. Metallic colors are generally defined as colors having gonioapparent effects. For example, the American Society of Testing Methods (ASTM) document F284 defines metallic as "pertaining to the appearance of a gonioapparent material containing metal flake." Metallic basecoat colors may be produced using metallic flake pigments like aluminum flake pigments, copper flake pigments, zinc flake pigments, stainless steel flake pigments, and bronze flake pigments and/or using pearlescent flake pigments including treated micas like titanium dioxide-coated mica pigments and iron oxide-coated mica pigments to give the coatings a different appearance when viewed at different angles. Unlike the solid color pigments, the flake pigments do not agglomerate and are not ground under high shear because high shear would break or bend the flakes or their crystalline morphology, diminishing or destroying the gonioapparent effects. The flake pigments may be dispersed with the acrylic polymer, but may also be dispersed with the crosslinker or another film-forming resin or polymer, by stirring under low shear.

[0025] When the coating composition is a basecoat composition, it typically has a pigment to binder ratio of about 0.04 to about 1.0, depending on the pigments used.

[0026] The coating compositions of the present invention preferably also include a film-forming polymer or resin other than the acrylic polymer dispersing the pigment. Suitable examples of such film-forming polymers and resins include, without limitation, acrylic polymers, polyesters, polyurethanes, and modified polyurethanes such as graft copolymers. The film-forming polymers and resins generally have reactive groups, such as active hydrogen groups, particularly hydroxyl groups.

[0027] The coating compositions of the present invention preferably also include a crosslinker component. The crosslinker component includes one or more crosslinkers reactive with active hydrogen functionality. Examples of crosslinkers reactive with active hydrogen functionality include, without limitation, materials having active methylol or methylalkoxy groups, including aminoplast resins or phenol/formaldehyde adducts; blocked polyisocyanate curing agents; tris(alkoxy carbonylamino)triazines (available from Cytac Industries under the name TACT); and combinations thereof. Suitable aminoplast resins are amine/aldehyde condensates, preferably at least partially etherified, and most preferably fully etherified. Melamine and urea are preferred amines, but other triazines, triazoles, diazines, guanidines, or guanamines may also be used to prepare the alkylated amine/aldehyde aminoplast resins crosslinking agents. The aminoplast resins are preferably amine/formaldehyde condensates, although other aldehydes, such as acetaldehyde, crotonaldehyde, and benzaldehyde, may be used. Non-limiting examples of preferred aminoplast resins include monomeric or polymeric melamine formaldehyde resins, including melamine resins that are partially or fully alkylated using alcohols that preferably have one to six, more preferably one to four, carbon atoms, such as hexamethoxy methylated melamine; urea-formaldehyde resins including methylol ureas and siloxy ureas such as butylated urea formaldehyde resin, alkylated benzoguanimines, guanyl ureas, guanidines, biguanidines, polyguanidines, and the like. Monomeric melamine formaldehyde resins are particularly preferred. The preferred alkylated melamine formaldehyde resins are water miscible or water soluble. Examples of blocked polyisocyanates include isocyanurates of toluene diisocyanate, isophorone diisocyanate, and hexamethylene diisocyanate blocked with a blocking agent such as an alcohol, an oxime, or a secondary amine such as pyrazole or substituted pyrazole.

[0028] The crosslinker component preferably is from about 2% by weight to about 40% by weight, and more preferably from about 15% by weight to about 35% by weight, and particularly preferably about 20% to about 30% by weight of the combined nonvolatile weights of the film-forming materials.

[0029] The coating compositions may include one or more catalysts. The type of catalyst depends upon the particular crosslinker component composition utilized. Useful catalysts include, without limitation, blocked acid catalysts, such as para-toluene sulfonic acid, dodecylbenzene sulfonic acid, and dinonylnaphthylene disulfonic acid blocked with amines; phenyl acid phosphate, monobutyl maleate, and butyl phosphate, hydroxy phosphate ester; Lewis acids, zinc salts, and tin salts, including dibutyl tin dilaurate and dibutyl tin oxide.

[0030] The coating compositions may be solventborne or waterborne. Suitable solvents for solventborne compositions

include, without limitation, esters, alcohols, and substituted aromatic solvents. Waterborne compositions may include, in addition to water, organic cosolvents such as, without limitation, alkyl ethers of propylene and ethylene glycol and dimers thereof.

[0031] Other conventional materials, such as flow control or rheology control agents, antioxidants, hindered amine light absorbers, and other conventional coatings additives may be added to the compositions.

[0032] The coating compositions of the present invention are preferably applied as basecoats on automotive articles, such as metal or plastic automotive bodies or elastomeric fascia. It is preferred to have a layer of a primer surfacer before application of the basecoat coating composition of the invention. A clearcoat composition is preferably applied over the basecoat composition.

[0033] A preferred composite coating of the invention has, as one layer, a basecoat coating layer that is obtained from the basecoat composition of the invention. The composite coating has a clearcoat layer applied over the basecoat coating layer. Crosslinking compositions are preferred for forming the clearcoat layer. Coatings of this type are well-known in the art and include waterborne compositions as well as solventborne compositions. For example, the clearcoat according to U.S. Pat. No. 5,474,811 may be applied wet-on-wet over a layer of the basecoat composition. Polymers known in the art to be useful in clearcoat compositions include, without limitation, acrylics, vinyl, polyurethanes, polycarbonates, polyesters, alkyds, and polysiloxanes. Acrylics and polyurethanes are preferred. Thermoset clearcoat compositions are also preferred, and, to that end, preferred polymers comprise one or more kinds of crosslinkable functional groups, such as carbamate, hydroxy, isocyanate, amine, epoxy, acrylate, vinyl, silane, acetoacetate, and so on. The polymer may be self-crosslinking, or, preferably, the composition may include a crosslinking agent such as a polyisocyanate or an aminoplast resin of the kind described above. In one embodiment, waterborne clearcoat compositions having low volatile organic content are used. The waterborne clearcoat compositions preferably has a volatile organic content of less than about 1.5, more preferably less than about 1.3.

[0034] Each layer of the composite coatings of the invention can be applied to an article to be coated according to any of a number of techniques well-known in the art. These include, for example, spray coating, dip coating, roll coating, curtain coating, and the like. If an initial electrocoat primer layer is applied to a metallic substrate, the electrocoat primer is applied by electrodeposition. For automotive applications, the primer surfacer coating composition, basecoat composition of the invention, and the clearcoat composition layers are preferably applied by spray coating, particularly electrostatic spray methods. Coating layers of one mil or more are usually applied in two or more coats, separated by a time sufficient to allow some of the solvent or aqueous medium to evaporate, or "flash," from the applied layer. The flash may be at ambient or elevated temperatures, for example, the flash may use radiant heat. The coats as applied can be from 0.5 mil up to 3 mils dry, and a sufficient number of coats are applied to yield the desired final coating thickness.

[0035] Basecoat-clearcoat topcoats are usually applied wet-on-wet. The compositions are applied in coats separated

by a flash, as described above, with a flash also between the last coat of the basecoat composition and the first coat of the clearcoat composition. The two coating layers are then cured simultaneously. Preferably, the cured basecoat layer is 0.5 to 1.5 mils thick, preferably a thickness at least to hiding, and the cured clear coat layer is 1 to 3 mils, more preferably 1.6 to 2.2 mils, thick.

[0036] The coating compositions described are preferably cured with heat. Curing temperatures are preferably from about 70° C. to about 180° C., and particularly preferably from about 170° F. to about 200° F. for a composition including an unblocked acid catalyst, or from about 240° F. to about 275° F. for a composition including a blocked acid catalyst. Typical curing times at these temperatures range from 15 to 60 minutes, and preferably the temperature is chosen to allow a cure time of from about 15 to about 30 minutes. In a preferred embodiment, the coated article is an automotive body or part.

[0037] The invention is further described in the following examples. The examples are merely illustrative and do not in any way limit the scope of the invention as described and claimed.

EXAMPLES

Example 1

Pigment Dispersant of the Invention

[0038] A suitable reactor was charged with 450 parts by weight of propylene glycol monopropyl ether, which was heated under an inert atmosphere to 140° C. Then a mixture of 92 parts by weight of Sipomer B-CEA (Rhodia, Cranbury, N.J.), 132.5 parts by weight of 2-hydroxyethyl acrylate, 32.5 parts by weight of methyl methacrylate, 128.6 parts by weight of butyl methacrylate, 42.6 parts by weight of 2-ethylhexyl acrylate, 123.7 parts by weight of styrene, 32.5 parts by weight of 1-(2-methacryloyloxyethyl)-2-imidazolidinone, 65 parts by weight of M-230 (Kowa American Corp. NY, N.Y.), 8.3 parts by weight of t-butyl peracetate, and 8.3 parts by weight of odorless mineral spirits was added to the reactor over a 3-hour time period. Next 20 parts by weight of propylene glycol monopropyl ether were added and the reaction mixture kept at 140° C. for 50 minutes. The reaction mixture was cooled to 110° C., and a mixture of 9.7 parts by weight of t-butyl peroxy-2-ethylhexanoate and 20 parts by weight of propylene glycol monopropyl ether was added over a 20-minute time period. Then 10 parts by weight of propylene glycol monopropyl ether were added and the reaction mixture held at 110° C. for 1 hour. The reaction mixture was then cooled. 167 parts of a 20% mixture of aminopropanol in deionized water was added, followed by 346.4 parts of deionized water. The final resin had a measured nonvolatile content of 41.2% by weight.

Example 2

Red Pigment Composition According to the Invention

[0039] A red pigment composition was prepared by adding 14.31 parts by weight perylene pigment (C.I. Pigment Red 179) to a stirred mixture of 33.48 parts by weight pigment dispersant resin prepared in accordance with Example 1, 4.58 parts by weight propylene glycol n-propyl ether, 45.71

parts deionized water, and 1.92 parts by weight of a commercial polyalkylene additive. The resultant mixture was stirred on a Cowles disperser for thirty minutes and milled in an Eiger bead mill for two and a half hours.

Comparative Example A

Comparative Red Pigment Composition

[0040] A comparative red pigment composition was prepared by adding 14.31 parts by weight perylene pigment (C.I. Pigment Red 179) to a stirred mixture of 16.74 parts by weight of an acrylic grind resin that was not prepared according to the invention, 16.74 parts by weight of a polyurethane resin, 4.58 parts by weight propylene glycol n-propyl ether, 45.71 parts deionized water, and 1.92 parts by weight of a commercial polyalkylene additive. The resultant mixture was stirred on a Cowles disperser for thirty minutes and milled in an Eiger bead mill for two and a half hours.

Example 3

Blue Pigment Composition According to the Invention

[0041] A blue pigment composition was prepared by adding 14.28 parts by weight indanthrone pigment (C.I. Pigment Blue 60) to a stirred mixture of 19.04 parts by weight pigment dispersant resin prepared in accordance with Example 1, 8.57 parts by weight propylene glycol n-propyl ether, and 58.11 parts by weight deionized water. The resultant mixture was stirred on a Cowles disperser for thirty minutes and milled in an Eiger bead mill for ten hours.

Comparative Example B

Comparative Blue Pigment Composition

[0042] A blue pigment paste was prepared by adding 14.28 parts by weight indanthrone pigment (C.I. Pigment Blue 60) to a stirred mixture of 19.04 parts by weight of an acrylic grind resin that was not prepared according to the invention, 8.57 parts by weight propylene glycol n-propyl ether, and 58.11 parts by weight deionized water. The resultant mixture was stirred on a Cowles disperser for thirty minutes and milled in an Eiger bead mill for ten hours.

Example 4

Coating Composition According to the Invention

[0043] A coating composition was prepared that contained the red pigment composition of Example 2 by combining with rapid stirring 79.94 parts by weight of an unpigmented basecoat mixture, 16.18 parts by weight of the red pigment composition of Example 2, 1.16 parts by weight of a black tinting paste (prepared by mixing an anionic polyurethane resin with carbon black pigment, stirring the mixture on a Cowles disperser for thirty minutes, and milling the stirred mixture in an Eiger bead mill for two and one-half hours), and 7.72 parts by weight of a mica pigment dispersion (prepared by slurring 2.20 parts by weight iron oxide coated mica in a combination of 2.54 parts by weight of polyester resin and 2.54 parts by weight propylene glycol

n-propyl ether, then adding 0.44 parts by weight of a 20% aqueous solution of amine). Stirring was continued for about thirty minutes.

Comparative Example C

Comparative Coating Composition

[0044] A coating composition was prepared according to Example 4, except that the 16.18 parts by weight of the red pigment composition of Example 2 was replaced by 16.18 parts by weight of the comparative red pigment composition of Comparative Example A.

Example 5

Coating Composition According to the Invention

[0045] A coating composition was prepared that contained the blue pigment composition of Example 3 by combining with rapid stirring 82.62 parts by weight of the unpigmented basecoat mixture used in Example 4 and 7.83 parts by weight of the blue pigment composition of Example 3 premixed with 9.55 parts by weight of an aluminum pigment dispersion (prepared by slurring 4.01 parts by weight aluminum pigment in a combination of 2.55 parts by weight of polyester resin and 2.55 parts by weight propylene glycol n-propyl ether, then adding 0.44 parts by weight of a 20% aqueous solution of amine). Stirring was continued for about thirty minutes.

Comparative Example D

Comparative Coating Composition

[0046] A coating composition was prepared according to Example 5, except that the 7.83 parts by weight of the blue pigment composition of Example 3 was replaced by 7.83 parts by weight of the comparative blue pigment composition of Comparative Example B.

Testing of Coating Compositions

[0047] The coating compositions of Examples 4 and 5 and Comparative Examples C and D were applied as basecoats and cured according to established procedures and equipment.

[0048] The color development in the coatings and stability of the coating compositions were compared. The film derived from the coating composition of Example 4 and Example 5 showed excellent metallic effect as a result of good transparency in the red pigment and blue pigment, respectively. The coating compositions of Examples 4 and 5 showed no instability after makeup and storage.

[0049] The basecoat coating colors were measured by a goniospectrophotometer at 25 degrees from specular with results as indicated below.

Coating Composition	L* (brightness)	a* (red index)	b* (yellow index)
Example 4	26.3	40.2	20.4
Comparative Example C	24.9	38.8	19.7
Example 5	67.05	-6.24	-40.03
Comparative Example D	65.10	-6.85	-42.52

[0050] The description of the invention is merely exemplary in nature and, thus, variations that do not depart from the gist of the invention are intended to be within the scope of the invention. Such variations are not to be regarded as a departure from the spirit and scope of the invention.

1. A coating composition comprising at least one pigment dispersed in an acrylic polymer, wherein the acrylic polymer is polymerized from a mixture of ethylenically unsaturated monomers comprising:

- (a) one or more monomers having active hydrogen functionality;
- (b) at least about 5% by weight of one or more monomers selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methoxy-polyoxyethylene (meth)acrylates, ω -methoxy-poly(oxyethylene-co-oxypropylene) (meth)acrylates, and combinations thereof;
- (c) optionally hydroxyethylene ethyl urea (meth)acrylate; and
- (d) up to about 50 percent by weight of one or more monomers selected from the group consisting of aromatic polymerizable monomers,

wherein the monomers (b) and (c) combined are from about 5 to about 45 percent by weight of the mixture of ethylenically unsaturated monomers.

2. A coating composition according to claim 1, wherein monomer (a) is selected from the group consisting of acrylamide, methacrylamide, beta-hydroxycarbamate acrylate, beta-hydroxycarbamate methacrylate, hydroxyalkyl(meth)acrylates, hydroxyethyl(meth)acrylate, hydroxypropyl(meth)acrylate, hydroxybutyl(meth)acrylate, esters of epsilon caprolactone and hydroxyalkyl(meth)acrylates, mono(meth)acrylates of polyethylene glycols, and combinations thereof.

3. A coating composition according to claim 1, wherein the acrylic polymer has a weight average molecular weight of from about 8,000 to about 70,000.

4. A coating composition according to claim 1, wherein the acrylic polymer has a carboxylic acid equivalent weight of from about 800 to about 2000.

5. A coating composition according to claim 1, wherein the acrylic polymer has an active hydrogen group equivalent weight of from about 400 to about 2000.

6. A coating composition according to claim 1, wherein monomer (b) comprises a β -carboxyethyl acrylate.

7. A coating composition according to claim 1, wherein monomer (b) comprises an ω -methoxy-polyoxyethylene (meth)acrylate.

8. A coating composition according to claim 1, wherein the mixture of ethylenically unsaturated monomers comprises from about 1 to about 10 weight percent of hydroxyethylene ethyl urea (meth)acrylate.

9. A coating composition according to claim 1, wherein the mixture of ethylenically unsaturated monomers comprises from about 5 to about 50 weight percent of styrene.

10. A coating composition according to claim 1, wherein the coating composition is a solventborne coating composition.

11. A waterborne basecoat composition, comprising an aqueous dispersion having at least one pigment dispersed by an acrylic polymer, wherein the acrylic polymer is polymerized from a mixture of ethylenically unsaturated monomers comprising:

- (a) one or more monomers having active hydrogen functionality;
- (b) at least about 5% by weight of one or more monomers selected from the group consisting of monomers having a carboxylic acid group in which the carbonyl carbon is separated from the closest ethylenically unsaturated carbon by at least four atoms, ω -methyloxy-polyoxyethylene (meth)acrylates, and combinations thereof;
- (c) optionally hydroxyethylene ethyl urea (meth)acrylate; and
- (d) up to about 50 percent by weight of one or more monomers selected from the group consisting of aromatic polymerizable monomers,

wherein the monomers (b) and (c) combined are from about 5 to about 45 percent by weight of the mixture of ethylenically unsaturated monomers.

12. A waterborne basecoat composition according to claim 11, further comprising a film-forming polymer other than the acrylic polymer dispersing the pigment.

13. A waterborne basecoat composition according to claim 12, further comprising a crosslinking agent.

14. A waterborne basecoat composition according to claim 12, wherein monomer (a) is selected from the group consisting of acrylamide, methacrylamide, beta-hydroxycarbamate acrylate, beta-hydroxycarbamate methacrylate,

hydroxyalkyl(meth)acrylates, hydroxyethyl(meth)acrylate, hydroxypropyl(meth)acrylate, hydroxybutyl (meth)acrylate, esters of epsilon caprolactone and hydroxyalkyl(meth)acrylates, mono(meth)acrylates of polyethylene glycols, and combinations thereof.

15. A waterborne basecoat composition according to claim 12, wherein the acrylic polymer has a weight average molecular weight of from about 8,000 to about 70,000.

16. A waterborne basecoat composition according to claim 12, wherein the acrylic polymer has a carboxylic acid equivalent weight of from about 800 to about 2000.

17. A waterborne basecoat composition according to claim 12, wherein the acrylic polymer has an active hydrogen group equivalent weight of from about 400 to about 2000.

18. A waterborne basecoat composition according to claim 12, wherein monomer (b) comprises a β -carboxyethyl acrylate.

19. A waterborne basecoat composition according to claim 12, wherein monomer (b) comprises an ω -methyloxy-polyoxyethylene (meth)acrylate.

20. A waterborne basecoat composition according to claim 12, wherein the mixture of ethylenically unsaturated monomers comprises from about 1 to about 10 weight percent of hydroxyethylene ethyl urea (meth)acrylate.

21. A waterborne basecoat composition according to claim 12, wherein the mixture of ethylenically unsaturated monomers comprises from about 5 to about 50 weight percent of styrene.

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