Title: CLEARCOAT COMPOSITION AND METHOD OF END OF LINE REPAIR USING THE CLEARCOAT COMPOSITION

Abstract: Disclosed is a solventborne clearcoat composition comprising a blocked polyisocyanate and a silane functional polymer or silane functional oligomer that can be cured at a relatively low curing temperature. Also disclosed is a method for the end of line repair of a substrate during its manufacture using the solventborne clearcoat composition.
FIELD OF THE DISCLOSURE

[01] The present disclosure is directed to a solventborne clearcoat composition containing blocked isocyanate, silane functional polymer and optionally, melamine crosslinking agents that can be cured at a relatively low temperature. The present disclosure also relates to a method for the end of line repair of a defect in an original equipment manufacture coating composition that can occur during the manufacturing process of substrates, especially automobiles. The repair coatings can be cured at relatively low temperatures and still provide the desired appearance and physical properties of the original cured coating composition.

BACKGROUND OF DISCLOSURE

[02] The painting of automobiles during their manufacture is a time and energy intensive process. The painting process comprises many steps and, in general, at least four different coating layers. The first layer can be an electrocoat layer which provides a durable corrosion resistant layer. The electrocoat layer is typically cured by baking prior to the application of a primer layer. The primer layer provides a smooth and chip resistant layer is also usually baked prior to the application of the next layer which is typically a color or basecoat layer. The basecoat layer provides the color area for the automobile. One or more layers of basecoat composition are typically applied, optionally followed by a flash step to remove at least a portion of the solvent. Finally, one or more layers of a clearcoat composition can be applied to provide a durable high gloss appearance to the substrate. The applied layers of basecoat composition and clearcoat composition are usually cured in the same baking step.

[03] During the painting and manufacture of the automobile, it is not uncommon to have one or more defects that need to be repaired. In a typical end of line repair process, a defect is identified, and the defect and an area around the defect is removed, for example, by sanding. Once the defect has been removed, the area around the repair area can optionally be masked to protect the undamaged area from both overspray and the heat of curing the repair coatings. One or more layers of repair coating compositions can be used to fix the damaged area so that it is virtually indistinguishable from the undamaged portions. The coating compositions that are used to repair the damaged areas can be the same type of coating compositions that
were originally applied. However, due to the relatively high curing temperature of the original coating compositions, it is more common to use different coating compositions that have relatively lower curing temperatures. It is important that the repair coating compositions provide the same color, clarity, gloss and overall appearance to the repaired area and that they have similar physical properties such as, for example, humidity resistance, polishability, and adhesion. A properly repaired defect should be indistinguishable from the originally applied coatings for the service life of the automobile.

[04] Development of an end of line repair clearcoat composition for use over a waterborne basecoat composition while having a low baking temperature and still providing all of the necessary properties has been particularly challenging. The general requirement in the automotive industry is to have repair coatings that can be cured at lower temperatures than the originally applied coating compositions. The lower baking temperatures can necessitate the use of repair clearcoat compositions with a different chemistry than was used in the original clearcoat composition. The different chemistry of the repair clearcoat composition can have a noticeable haze versus the original clearcoat composition and can have adhesion problems when applied to the original clearcoat composition. Therefore, a need still exists for an end of line repair clearcoat composition that can be used over waterborne and/or solventborne basecoat compositions and that can be baked at relatively low temperatures while still providing all of the required appearance values and physical properties of the originally applied coatings.

STATEMENT OF THE DISCLOSURE

[05] The present disclosure is related to a clearcoat composition. The clearcoat composition is a solventborne clearcoat composition comprising a film forming binder wherein the film forming binder comprises;

a) blocked polyisocyanate;

b) silane functional polymer or silane functional oligomer;

c) optionally, melamine resin and/or a crosslinkable polymer;

d) optionally, another crosslinkable polymer; and

wherein the solventborne clearcoat composition further comprises one or more crosslinking catalysts.

[06] Also disclosed is a method for coating a substrate and a method for the end of line repair of a coated substrate using the solventborne clearcoat composition.
BRIEF DESCRIPTION OF DRAWING

[07] Figure 1 is a graph showing the effect of various baking temperatures on the formation of free isocyanate groups for Comparative Clearcoat C.

[08] Figure 2 is a graph showing the effect of various baking temperatures on the formation of free isocyanate groups for Clearcoat Example 2.

[09] Figure 3 is a graph showing the effect of various baking temperatures on the formation of free isocyanate groups for Comparative Clearcoat D.

[10] Figure 4 is a graph showing the effect of various baking temperatures on the formation of free isocyanate groups for Clearcoat Example 3.

[11] Figure 5 shows a comparison of Comparative Clearcoat C and Clearcoat 2.

[12] Figure 6 shows a comparison of Comparative Clearcoat D and Clearcoat 3.

DETAILED DESCRIPTION

[13] The features and advantages of the present disclosure will be more readily understood, by those of ordinary skill in the art, from reading the following detailed description. It is to be appreciated that certain features of the disclosure, which are, for clarity, described above and below in the context of separate embodiments, may also be provided in combination in a single embodiment. Conversely, various features of the disclosure that are, for brevity, described in the context of a single embodiment, may also be provided separately or in any sub-combination. In addition, references in the singular may also include the plural (for example, "a" and "an" may refer to one, or one or more) unless the context specifically states otherwise.

[14] The use of numerical values in the various ranges specified in this application, unless expressly indicated otherwise, are stated as approximations as though the minimum and maximum values within the stated ranges were both proceeded by the word "about". In this manner, slight variations above and below the stated ranges can be used to achieve substantially the same results as values within the ranges. Also, the disclosure of these ranges is intended as a continuous range including every value between the minimum and maximum values.

[15] As used herein: the term (meth)acrylate means acrylate and/or methacrylate and the term (meth)acrylic means acrylic and/or methacrylic.

[16] The phrase 'silane functional' means that the described component can have at least one hydrolyzable silane group. In some embodiments, the hydrolyzable silane group has a formula according to -Si-(OR)\(_3\)\(_x\)R\(_1\)_\(_x\) wherein R is an alkyl group having in the range of from 1 to 4 carbon atoms, R\(_1\) is an alkyl group having in the
range of from 1 to 4 carbon atoms and \( x \) is 0, 1 or 2. Polysiloxanes, that is, compounds having -Si-O-Si- bonds, are excluded from this definition.

The disclosure provides temperatures for the curing of the applied layer or layers of the solventborne clearcoat composition. The given temperature and/or temperature ranges describe the temperatures to which the solventborne coating composition is heated to cure the coating composition. Any fractional temperature should be rounded to the closest whole number temperature, for example, a curing temperature of 87.7°C will be considered to be 88°C. During the curing of an applied layer of solventborne clearcoat composition, the temperature of the solventborne coating composition can be monitored in a number of ways, including, for example, using an infrared thermometer. Other methods to measure the curing temperature are known to those in the art and may be employed.

As used herein, the term clearcoat refers to the state of a dried and cured layer of the composition. Prior to drying and curing, the clearcoat composition may be transparent, translucent or opaque in appearance.

As used herein, the phrase 'manufacturing line' means the path that a substrate takes during its original manufacture. The substrate can be moved continuously along the line while it is being manufactured, it can be moved from one station to the next during its manufacture or the substrate may be manufactured using a combination of individual stations and a moving line. In a typical automobile manufacturing facility, the movement of the substrate along the line can be facilitated by the use of robots or other power equipment, or it may be physically moved by a person or persons.

It has been found that the use of a solventborne clearcoat composition comprising a film forming binder wherein the film forming binder comprises or consists essentially of a blocked polyisocyanate and a silane functional polymer and/or silane functional oligomer can produce a solventborne clearcoat composition that has a relatively lower curing temperature than a solventborne clearcoat composition without the silane functional polymer and/or oligomer. In some embodiments, the film-forming binder can further include melamine resin and/or another crosslinkable polymer that is different than the silane functional polymer/oligomer. As used herein, the term solventborne means that the liquid carrier of a coating composition comprises less than 50 percent by weight of water, based on the total amount of liquid carrier. In some embodiments, the liquid carrier comprises less than 10 percent by weight of water, and in further embodiments, the liquid carrier comprises less than 1 percent by weight of water.
It has also been found that the curing temperature can be made even lower by using a waterborne basecoat that comprises a blocked acid catalyst wherein the acid blocking agent is a weak amine, such as, for example, n-methylmorpholine. As used herein, the term weak amine refers to an ammonium ion that can disassociate from a counter acid anion at a temperature of less than or equal to the curing temperature of the solventborne clearcoat composition to form an amine and an acid. As used herein, the term waterborne means that the liquid carrier of a coating composition comprises greater than or equal to 50 percent by weight of water, based on the total amount of liquid carrier. In some embodiments, the liquid carrier can comprise more than 60 percent by weight of water and, in still further embodiments, the liquid carrier can comprise more than 70 percent by weight of water.

In some embodiments, the solventborne clearcoat composition comprises a film forming binder wherein the film forming binder comprises or consists essentially of:

a) a blocked polyisocyanate;

b) a silane functional polymer or silane functional oligomer;

c) optionally melamine resin;

d) optionally another crosslinkable polymer; and

wherein the solventborne coating composition further comprises one or more crosslinking catalysts. In further embodiments, the film forming binder comprises or consists essentially of in the range of from 5 to 30 percent by weight of blocked polyisocyanate, in the range of from 20 to 80 percent by weight of silane functional polymer or oligomer; in the range of from 0 to 30 percent by weight of melamine resin; in the range of from 0 to 40 percent by weight of another crosslinkable polymer; and the solventborne clearcoat composition further comprises in the range of from 0.5 to 4 percent by weight of crosslinking catalyst, wherein all percentages by weight are based on the total amount of film forming binder. In still further embodiments, the film forming binder comprises or consists essentially of in the range of from 10 to 25 percent by weight of blocked polyisocyanate, in the range of from 30 to 70 percent by weight of silane functional polymer or oligomer; in the range of from 5 to 25 percent by weight of melamine resin; in the range of from 5 to 30 percent by weight of another crosslinkable polymer; and the solventborne clearcoat composition further comprises in the range of from 0.7 to 3.5 percent by weight of crosslinking catalyst, wherein all percentages by weight are based on the total amount of film forming binder. In still further embodiments, the film forming binder comprises or consists essentially of in the range of from 12 to 20 percent by weight of blocked polyisocyanate, in the range of from 35 to 60 percent by weight of silane.
functional polymer or oligomer; in the range of from 5 to 20 percent by weight of melamine resin; in the range of from 10 to 25 percent by weight of another crosslinkable polymer; and the solventborne clearcoat composition further comprises in the range of from 1 to 3 percent by weight of crosslinking catalyst, wherein all percentages by weight are based on the total amount of film forming binder.

[23] The blocked polyisocyanate can be a polyisocyanate blocked by any of the known blocking agents. In some embodiments, the blocking agents can be selected from the group consisting of pyrazole, alkyl pyrazoles, dialkyl pyrazoles, imidazoles and pyridines. In some embodiments, the blocking agent is a pyrazole compound having a formula:

\[
\text{[R\text{\(^2\)q}}
\]

wherein each \(R^2\) is independently an alkyl group having in the range of from 1 to 4 carbon atoms, an alkenyl group having in the range of from 2 to 4 carbon atoms, an aromatic group, or an ester group having 1 to 4 carbon atoms in the ester portion; and \(q\) is an integer from 0 to 3. In further embodiments, \(q\) is 2 and both \(R^2\) groups are methyl.

[24] The blocked polyisocyanate can be produced from any of the known polyisocyanates. In some embodiments, the polyisocyanate can be an aliphatic diisocyanate, an aromatic diisocyanate or a diisocyanate containing both aliphatic and aromatic groups. In other embodiments, homopolymers and copolymers of polyisocyanates can be used. Such polymeric polyisocyanates are well known in the art and can include, for example, the isocyanurates, allophanates, biurets and/or uretidiones of diisocyanates or polyisocyanates. In some embodiments, aliphatic polyisocyanates are used since the presence of aromatic polyisocyanates can cause yellowing of the coating composition over time. Suitable polyisocyanates can include, for example, hexamethylene diisocyanate, isophorone diisocyanate, 4,4'-dicyclohexyl methane diisocyanate, 1,4-cyclohexane diisocyanate, 1,5-naphthalene diisocyanate, 4,6-xylene diisocyanate, 2,4-toluene diisocyanate, 2,6-toluene diisocyanate, 4,4-diphenylmethane diisocyanate, 1,2-propylene diisocyanate, tetramethylene diisocyanate, 2,3-butylene diisocyanate, octamethylene diisocyanate, 2,2,4-trimethyl hexamethylene diisocyanate, dodecamethylene diisocyanate, omega-dipropyl ether diisocyanate, 1,3-cyclopentane diisocyanate, 1,2-cyclohexane...
diisocyanate, 4-methyl-1,3-diisocyanatocyclohexane, 3,3’-dimethyl-
dicyclohexylmethane 4,4’-diisocyanate or a combination thereof.
[25] A silane functional polymer and/or silane functional oligomer can be included as part of the film forming binder. In some embodiments, the silane functional polymer can comprise or consist essentially of silane functional (meth)acrylate polymers, silane functional polyesters, silane functional polyurethanes, silane functional polyesterurethanes or a combination thereof. Silane functional polymers and/or silane functional oligomers are well known in the art and, in some embodiments, can have a number average molecular weight in the range of from 300 to 100,000 Daltons. In other embodiments, the number average molecular weight can be in the range of from 500 to 50,000 Daltons, and in still further embodiments, the number average molecular weight can be in the range of from 1000 to 20,000 Daltons. Suitable silane functional oligomers can, in some embodiments, comprise a compound, such as, for example, 3-aminopropyl trimethoxysilane, or, in other embodiments, can comprise an oligomeric component comprising polymerized silane functional (meth)acrylate monomers, having a number average weight in the thousands of Daltons.
[26] In some embodiments, the silane functional (meth)acrylate polymer or silane functional oligomer can be produced by the polymerization of a monomer mixture comprising or consisting essentially of in the range of from 20 to 95 percent by weight of alkyl (meth)acrylate monomers and 5 to 80 percent by weight of silane functional ethylenically unsaturated monomers. In other embodiments, the silane functional polymer or silane functional oligomer can be produced by the polymerization of a monomer mixture comprising or consisting essentially of in the range of from 25 to 75 percent by weight of alkyl (meth)acrylate monomers, 10 to 40 percent by weight of silane functional ethylenically unsaturated monomers and 15 to 65 percent by weight other monomers. All percentages by weight are based on the total weight of monomers in the monomer mixture.
[27] The alkyl (meth)acrylate monomers can contain crosslinkable functional groups or they can be free of crosslinkable functional groups. Suitable crosslinkable functional groups can include, for example, hydroxyls, thiols, amines, epoxies, urethanes, carboxylic acids or a combination thereof. In some embodiments, at least a portion (greater than 10 percent by weight) of the alkyl (meth)acrylate monomers in the monomer mixture contain a crosslinkable functional group. In other embodiments, in the range of from 10 to 80 percent by weight of the (meth)acrylate monomers in the monomer mixture contain a crosslinkable functional group, wherein the percentage by weight is based on the total weight of the monomer mixture.
Suitable (meth)acrylate monomers that contain a crosslinkable functional group can include, for example, 2-hydroxyethyl (meth)acrylate, 2-hydroxypropyl (meth)acrylate, 3-hydroxyl propyl (meth)acrylate, 2-amo-noethyl (meth)acrylate, N-t-butyl aminoethy1 (meth)acrylate, glycidyl (meth)acrylate, 2-mercaptoethyl (meth)acrylate, (meth)acrylic acid or a combination thereof. Any silane functional monomers that may be present in the monomer mixture are not included in the at least a portion of monomers that contain a crosslinkable functional group. Suitable (meth)acrylate monomers that are free from crosslinkable functional groups can include, for example, alkyl (meth)acrylates having in the range of from 1 to 20 carbon atoms in the ester portion, such as, for example, methyl (meth)acrylate, ethyl (meth)acrylate, propyl (meth)acrylate, butyl (meth)acrylate, cyclohexyl (meth)acrylate, isobornyl (meth)acrylate, or a combination thereof. The ester portion can be linear, branched, cyclic or a combination thereof.

[28] Suitable silane functional ethylenically unsaturated monomers can include silane functional (meth)acrylate monomers and/or silane functional vinyl monomers. In some embodiments, the silane functional ethylenically unsaturated monomer can include monomers having a structure according to the formula;

\[
\begin{align*}
  &\text{R}^3 \\
  &\text{O} \\
  &\text{Si(OR)_{3-x}} \text{R}^4
\end{align*}
\]

wherein \( R, R^1 \) and \( x \) are as defined previously, \( R^3 \) is \( \text{H} \) or \( \text{CH}_3 \) and \( R^4 \) is an optionally substituted alkyl group having in the range of from 1 to 10 carbon atoms that can be linear, branched, cycloaliphatic or a combination thereof. Silane functional groups can also be introduced into a polymer or an oligomer by the post reaction of a polymer or an oligomer having suitable reactive functional groups with a silane functional molecule having a reactive functional group. In one example, a (meth)acrylate polymer containing hydroxyl functional groups can be produced that is subsequently contacted with an isocyanate functional silane molecule such as, for example, 3-isocyanatopropyl trimethoxysilane to produce a silane functional (meth)acrylate polymer. In some embodiments of this reaction, less than a stoichiometric amount of isocyanate functional silane molecules can be used for each hydroxyl group to provide a silane functional (meth)acrylic polymer having both hydroxyl and silane functional groups.

[29] The silane functional (meth)acrylate polymer and/or oligomer can also include other monomers. Suitable other monomers can include, for example, styrene, alpha-
methyl styrene, p-methyl styrene, vinyl acetate, acrylonitrile, methacrylonitrile, vinyl esters of VERSATIC® acid, vinyl chloride, vinylidene chloride, vinyl pyridine, vinyl pyrrolidone or a combination thereof.

[30] In other embodiments, the silane functional polymer can be silane functional polyesters, silane functional polyurethanes, silane functional polyesterurethanes or a combination thereof. In some embodiments, a branched polymer, such as for example, a branched polyester, a branched polyurethane or a branched polyesterurethane each having a plurality of hydroxyl groups can be produced according to known methods. At least a portion of the hydroxyl groups can then be contacted with a silane functional compound having at least one group that is reactive with a hydroxyl group, for example, 3-isocyanatopropyl trimethoxysilane, to form the silane functional polymer. In some embodiments, the silane functional polymer formed from the branched polymer contains both hydroxyl and silane functional groups.

[31] The film forming binder of the solventborne clearcoat composition can also comprise in the range of from 0 to 30 percent by weight of a melamine resin. In some embodiments, the melamine can be a monomeric melamine resin, a polymeric melamine resin or a combination thereof. Suitable melamine resins can include, for example, partially or fully alkylated melamine-formaldehyde condensates that contain methylol groups that have been further etherified with an alcohol, preferably one that contains 1 to 6 carbon atoms. Monohydric alcohols that can be employed for this purpose, include methanol, ethanol, propanol, butanol, and cyclohexanol. Suitable melamine resins are commercially available from, for example, Cytec Industries, Inc. under the trademark CYMEL® melamines and from Ineos Melamines, under the trade name RESIMENE® melamines.

[32] The crosslinkable polymer that is different than the silane functional polymer/oligomer can be any of the commonly known crosslinkable polymers. The crosslinkable polymer can be a (meth)acrylic polymer, a polyester, a polyether or a polyurethane. Combinations thereof can also be used. Typically, such polymers have a crosslinkable functional group that is a hydroxyl group or an amino group. In some embodiments, the crosslinkable polymer is an acrylic polymer having hydroxyl functional groups. In some embodiments, the crosslinkable polymer can be a solventborne crosslinkable polymer similar to many known in the art.

[33] The solventborne clearcoat composition can further comprise one or more crosslinking catalysts. In some embodiments, the catalysts can be selected from the group consisting of, for example, dialkyl tin diesters, dibutyl tin dilaurate, dibutyl tin diacetate, dibutyl tin dioxide, dibutyl tin dioctoate, tin octoate, aluminum titanate,
aluminum chelates, zirconium chelate, sulfonic acids, such as dodecylbenzene
sulfonic acid, alkyl acid phosphates, such as phenyl acid phosphate or a combination
to thereof. In other embodiments, the crosslinking catalysts can be a mixture of two or
more catalysts, such as, for example, a dialkyi tin diester and an acid catalyst. In still
further embodiments, a combination of dodecyl benzene sulfonic acid and dibutyl tin
dilaurate can be used.

[34] The solventborne clearcoat composition can further comprise additives that
are common to clearcoat compositions. Such additives can include, for example,
light stabilizers, light absorbers, organic solvents, rheology control agents, small
amounts of pigments that can be used to tint the clearcoat to provide enhanced
aesthetic effects, moisture scavengers, anti-popping agents, flow additives or a
combination thereof.

[35] The solventborne clearcoat composition is suitable for use over a variety of
substrates, such as, for example, plastic, wood, metal or previously coated
substrates. In some embodiments, the substrate can be a previously coated metal
substrate, comprising, for example, one or more layers of an electrocoat composition,
one or more layers of a primer composition, one or more layers of a basecoat
composition or a combination thereof. In still further embodiments, the solventborne
clearcoat composition can be applied over a basecoat composition that can be a
waterborne basecoat composition or a solventborne basecoat composition. If the
substrate is a waterborne basecoat, the waterborne basecoat composition, in some
embodiments, can comprise a blocked acid catalyst, such as, for example, an acid
catalyst blocked with a weak amine. In some embodiments, the solventborne
clearcoat composition can be applied to a dried and cured layer of a basecoat
composition, while in other embodiments, the solventborne clearcoat composition
can be applied wet-on-wet to a layer of basecoat composition. By "wet-on-wet" is
meant that one or more layers of a coating composition are applied to one or more
layers of another coating composition before the first applied layers have been cured.
As an example, one or more layers of basecoat composition can be applied to a
substrate followed by a flash drying step to remove at least a portion of the solvent of
the basecoat composition. The phrase "flash drying" or "flash" means a step that is
intended to remove at least a portion of the solvent, and, in general, is not intended
to initiate any curing of the applied coating composition. After the flash drying step,
one or more layers of the solventborne clearcoat composition can be applied to the
basecoat composition. The applied solventborne clearcoat composition can
optionally be flash dried to remove at least a portion of the solvent and then the
applied layers of basecoat and clearcoat composition can be baked to cure them.
In some embodiments, the method of producing a dried and cured layer of the solventborne clearcoat composition can comprise or consist essentially of the steps of:

1) applying a layer of the solventborne clearcoat composition to a substrate;
2) flash drying the applied layer of solventborne clearcoat composition to remove at least a portion of the solvent; and
3) curing the solventborne clearcoat composition by heating the applied layer of solventborne clearcoat composition to a temperature in the range of from 80°C to 115°C;

wherein the solventborne clearcoat composition comprises a film forming binder wherein the film forming binder comprises:

a) blocked polyisocyanate;

b) silane functional polymer or silane functional oligomer;

c) optionally, melamine resin; and

wherein the solventborne coating composition further comprises one or more crosslinking catalysts.

In further embodiments, the curing temperature of step 3) can be performed at a range of temperatures wherein the lowest temperature of the range can be from 80°C to 95°C and the upper temperature of the range can be from 104°C to 115°C.

In still further embodiments, the curing temperature of step 3) can be 80°C, 81°C, 82°C, 83°C, 84°C, 85°C, 86°C, 87°C, 88°C, 89°C, 90°C, 91°C, 92°C, 93°C, 94°C, 95°C, 96°C, 97°C, 98°C, 99°C, 100°C, 101°C, 102°C, 103°C, 104°C, 105°C, 106°C, 107°C, 108°C, 109°C, 110°C, 111°C, 112°C, 113°C, 114°C, 115°C or the curing temperature can be a range including any of the previous individual temperatures. Curing of the applied coating compositions can be accomplished by an infrared heating lamp, forced hot air heating or other heating source as is common in the art.

In other embodiments, step 1) can include the application of one or more layers of the solventborne clearcoat composition followed by step 2) flash drying the applied solventborne clearcoat composition to remove at least a portion of the solvent.

In some embodiments, the solventborne clearcoat composition can be useful for the end of line repair of an original equipment manufacture (OEM) coating composition. By "end of line repair" is meant that a defect of the OEM coating composition is repaired at any point in the manufacturing process after the original coating compositions of the product have been applied and cured. The process of
end of line repair of a defect of a dried and cured OEM coating composition on a substrate comprises or consists essentially of;

1) identifying an area to be repaired;
2) optionally, removing the substrate from a manufacturing line;
3) removing at least a portion of the coating composition around the area to be repaired;
4) applying one or more layers of a basecoat composition to at least a portion of the area to be repaired;
5) flashing the applied layer of basecoat composition to remove at least a portion of the solvent;
6) applying one or more layers of a solventborne clearcoat composition to at least a portion of the applied basecoat composition;
7) flashing the applied layer of solventborne clearcoat composition to remove at least a portion of the solvent; and
8) curing the applied layers of basecoat composition and solventborne clearcoat composition at a temperature in the range of from 80°C to 115°C
9) optionally, returning the substrate to the manufacturing line;

wherein the solventborne clearcoat composition comprises a film forming binder wherein the film forming binder comprises or consists essentially of;

a) a blocked polyisocyanate;

b) a silane functional polymer or silane functional oligomer;

c) optionally melamine resin; and

wherein the solventborne coating composition further comprises one or more crosslinking catalysts.

[40] The removing step 3) can be done by processes known to those in the art, such as, for example, mechanically grinding using, for example, abrasives or sand paper or can be done chemically, for example, by wiping the damaged area with a paint removal solvent. Optionally, the end of line repair can also include an additional step after step 6) of applying an additional layer of the solventborne clearcoat composition wherein the solventborne clearcoat composition has been diluted with an organic solvent. The dilution ratio can range from 1 part by weight of the solventborne clearcoat composition to 0.5 parts by weight of organic solvent up to a dilution ratio of 1 part by weight of the solventborne clearcoat composition to 3 parts by weight of organic solvent. In one embodiment, the dilution ratio is 1 part by weight of the solventborne clearcoat composition to 1 part by weight of organic
solvent. This is sometimes called a cut-in clearcoat and can help to smooth the applied layers of repair coating compositions creating a better appearance.

[41] In further embodiments, the curing temperature of step 8) can be performed at a range of temperatures wherein the lowest temperature of the range can be from 80°C to 95°C and the upper temperature of the range can be from 104°C to 115°C. In still further embodiments, the curing temperature of step 8) can be 80°C, 81°C, 82°C, 83°C, 84°C, 85°C, 86°C, 87°C, 88°C, 89°C, 90°C, 91°C, 92°C, 93°C, 94°C, 95°C, 96°C, 97°C, 98°C, 99°C, 100°C, 101°C, 102°C, 103°C, 104°C, 105°C, 106°C, 107°C, 108°C, 109°C, 110°C, 111°C, 112°C, 113°C, 114°C, 115°C or the curing temperature can be a range including any of the previous individual temperatures. Curing of the applied coating compositions can be accomplished by an infrared heating lamp, forced hot air heating or other heating source as is common in the art.

[42] In some embodiments, the solventborne clearcoat composition can be applied to a waterborne basecoat composition. In other embodiments, the solventborne clearcoat composition can be applied to a layer of a waterborne basecoat composition wherein the waterborne basecoat composition comprises a blocked acid catalyst. In still further embodiments, the waterborne basecoat composition can comprise a blocked acid catalyst that is an acid catalyst blocked with a weak amine. The acid catalyst can be those catalysts typically used in waterborne basecoats, for example, organic compounds containing one or more sulfonic acids groups. In one particular embodiment, the blocked acid catalyst can be the n-methyl morpholine salt of dodecylbenzene sulfonic acid. In other embodiments, the weak amine can be N,N-dimethyl isopropanol amine, or N,N-dimethyl ethanol amine, or amines having a pKa of less than 9.5 and boiling point of less than 150°C. While not wishing to be bound by theory, it is thought that the weak amine, after disassociation from the catalyst, can migrate out of the basecoat layer, into the applied layer of clearcoat composition and can facilitate the curing of the clearcoat composition.

[43] In still further embodiments, the solventborne clearcoat composition can be used as a refinish clearcoat for the repair of a damaged vehicle, for example, by the owner of the vehicle or by a refinish facility.

**EXAMPLES**

[44] The following examples demonstrate the use of a solventborne according to the disclosure, the process of end of line repair and demonstrate the relatively lower temperature needed to cure the coating composition when compared to coating compositions that do not contain all of the limitations of the disclosed composition.
The following ingredients/abbreviations are used in the examples. Unless otherwise specified, all ingredients are available from the Aldrich Chemical Company, Milwaukee, Wisconsin.

[45] 2-hydroxyethyl acrylate is abbreviated HEA.

[46] 2-hydroxyethyl methacrylate is abbreviated HEMA.

[47] Methacryloxypropyl trimethoxy silane is abbreviated MAPTS.

[48] Butyl methacrylate is abbreviated BMA.

[49] 2-ethyl hexyl acrylate is abbreviated EHA

[50] RESIMENE® CE-4514 is available from Ineos Melamines LLC, Springfield, Massachusetts.

[51] TINUUVIN® 328, 928, 079 and 123 light stabilizers are available from BASF, Florham Park, New Jersey.

[52] DISPARALON® L1984 is available from King Industries, Norwalk, Connecticut.

[53] Trimethyl Orthoacetate is available from Chem Central, Bedford Park, Illinois.

[54] AEROSIL® R972 silica is available from Evonik Degussa GmbH, Frankfurt, Germany.

[55] AROMATIC® 100 solvent is available from ExxonMobil, Houston, Texas.

[56] DESMODUR® BL-3575 dimethyl pyrazole blocked polyisocyanate is available from Bayer MaterialScience, Pittsburgh, Pennsylvania.

[57] **Preparation of Polymers 1 and 2**

Polymers 1 and 2 were prepared by copolymerizing, in the presence of a 2/1 SOLVESSO® 100 Aromatic Solvent/butanol mixture, the monomer mixtures described in Table 1 in the presence of 8 parts by weight of VAZO® 67 catalyst. The resulting polymer solution was determined to have a solids content of 70 percent and a viscosity of F-R on the Gardner Holdt scale measured at 25 °C. The polymer compositions have a weight average molecular weight of approximately 4,500 gram/mole as determined by GPC using polystyrene as a standard.

<table>
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<tr>
<th>TABLE 1</th>
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<tbody>
<tr>
<td>Polymer</td>
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<tr>
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<tr>
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<tr>
<td>MAPTS</td>
</tr>
<tr>
<td>Styrene</td>
</tr>
<tr>
<td>BMA</td>
</tr>
</tbody>
</table>
All amounts in Table 1 are in parts by weight.

Preparation of Clearcoat Common Soup 1

A clearcoat common soup was prepared by blending together the following ingredients in the order given:

TABLE 2

<table>
<thead>
<tr>
<th>Parts by weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESIMENE&lt;sup&gt;®&lt;/sup&gt; CE-4514 melamine</td>
</tr>
<tr>
<td>TINUVIN&lt;sup&gt;®&lt;/sup&gt; 328 solution&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>HALS Solution&lt;sup&gt;2&lt;/sup&gt;</td>
</tr>
<tr>
<td>Catalyst&lt;sup&gt;3&lt;/sup&gt;</td>
</tr>
<tr>
<td>Flow Aid&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Trimethyl orthoacetate</td>
</tr>
<tr>
<td>Silica Grind&lt;sup&gt;5&lt;/sup&gt;</td>
</tr>
<tr>
<td>Ethyl 3-Ethoxy Propionate</td>
</tr>
<tr>
<td>AROMATIC&lt;sup&gt;®&lt;/sup&gt; 100</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

1. 25% TINUVIN<sup>®</sup> 328 in AROMATIC<sup>®</sup> 100.
2. 28.6 parts TINUVIN<sup>®</sup> 928, 3.5 parts TINUVIN<sup>®</sup> 123, and 26.1 parts TINUVIN<sup>®</sup> 079 in 41.8 parts of AROMATIC<sup>®</sup> 100.
3. Dodecyl benzene sulfonic acid salt of 2-amino-2-methyl-1-propanol (AMP) supplied by King Industries, Norwalk, Connecticut, 33.6% in butanol.
4. DISPARLON<sup>®</sup> L-1984 acrylic polymer, 50% in AROMATIC<sup>®</sup> 100
5. 12% AEROSIL<sup>®</sup> R-972 silica ground with Polymer 1 in AROMATIC<sup>®</sup> 100 to produce a 37.2% solids dispersion.

Preparation of Clearcoat Example 1 and Comparative Clearcoats A and B

The Clearcoats of Table 3 were prepared by mixing the following ingredients. All amounts in Table 3 are given in parts by weight.

TABLE 3

<table>
<thead>
<tr>
<th>Clearcoat 1</th>
<th>Comparative Clearcoat A</th>
<th>Comparative Clearcoat B</th>
</tr>
</thead>
</table>
The OEM panels that were used in these examples were produced according to the following procedure. Steel panels were coated with CORMAX® VI electrocoat and cured. The electrocoated panels were then coated with a layer of primer surfacer (product code 554-DN082) which was then baked to cure the applied layer of coating composition according to the manufacturers' instructions. The primed panels were then coated with a waterborne OEM black basecoat (product code 562-AB921) and a clearcoat (product code RK-8032) and baked in a 135°C oven for 20 minutes. All of the coatings are available from DuPont Performance Coatings, Wilmington, Delaware.

In order to test the properties of the clearcoats of Table 3, the surface of the OEM panels were lightly sanded with a 1200 grit sandpaper. The waterborne OEM black basecoats were then spray applied in two coats with a 60 second flash period between the first and the second coat over the sanded OEM panels. The spray booth conditions were 24°C and 65% humidity. After a 5-minute flash at ambient condition, the waterborne basecoat were further flashed in an 82°C oven for 10 minutes. Two layers of the clearcoat compositions of Table 3 were applied with a 30 second flash at ambient between the first and the second clearcoat. The applied layers of clearcoat composition were further flashed for 30 minutes at the ambient booth temperature and then baked in a 90°C oven for 20 minutes. After cooling to ambient temperature, the panels were tested for Humidity Resistance using a General Motors humidity testing protocol, GMW 14729 and for Tukon Hardness. Tukon Hardness was tested using a Knoop diamond Indenter.

<table>
<thead>
<tr>
<th>Clearcoat Common Soup 1</th>
<th>42.5</th>
<th>42.5</th>
<th>42.5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Polymer 1</td>
<td>22.1</td>
<td>70.5</td>
<td>39.2</td>
</tr>
<tr>
<td>Silane functional polymer 1</td>
<td>46.3</td>
<td>0</td>
<td>46.3</td>
</tr>
<tr>
<td>DESMODUR® BL-3575 polyisocyanate</td>
<td>16</td>
<td>16</td>
<td>0</td>
</tr>
<tr>
<td>Dodecylbenzene sulfonic acid</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Dibutyl tin dilaurate</td>
<td>0.7</td>
<td>0.7</td>
<td>0.7</td>
</tr>
</tbody>
</table>

[65] The OEM panels that were used in these examples were produced according to the following procedure. Steel panels were coated with CORMAX® VI electrocoat and cured. The electrocoated panels were then coated with a layer of primer surfacer (product code 554-DN082) which was then baked to cure the applied layer of coating composition according to the manufacturers' instructions. The primed panels were then coated with a waterborne OEM black basecoat (product code 562-AB921) and a clearcoat (product code RK-8032) and baked in a 135°C oven for 20 minutes. All of the coatings are available from DuPont Performance Coatings, Wilmington, Delaware.

[66] In order to test the properties of the clearcoats of Table 3, the surface of the OEM panels were lightly sanded with a 1200 grit sandpaper. The waterborne OEM black basecoats were then spray applied in two coats with a 60 second flash period between the first and the second coat over the sanded OEM panels. The spray booth conditions were 24°C and 65% humidity. After a 5-minute flash at ambient condition, the waterborne basecoat were further flashed in an 82°C oven for 10 minutes. Two layers of the clearcoat compositions of Table 3 were applied with a 30 second flash at ambient between the first and the second clearcoat. The applied layers of clearcoat composition were further flashed for 30 minutes at the ambient booth temperature and then baked in a 90°C oven for 20 minutes. After cooling to ambient temperature, the panels were tested for Humidity Resistance using a General Motors humidity testing protocol, GMW 14729 and for Tukon Hardness. Tukon Hardness was tested using a Knoop diamond Indenter.
In order to test the adhesion of the solventborne clearcoat composition to a baked OEM clearcoat composition, each of the coating examples of Table 3 were reduced to 30 seconds #4 Ford cup with ethyl 3-ethoxy propionate and the reduced clearcoat compositions were then hand sprayed in two coats to a dry film thickness of about 40 microns onto the OEM panels with a 30 second flash between the first and the second clearcoat. The clearcoats were flashed for 30 minutes at ambient temperature and then baked in a 90°C oven for 24 minutes. These panels were then subjected to 10 day humidity and checked for haze, blistering, and clearcoat to clearcoat coat adhesion by Ford adhesion test method FLTM-B1106-1.

For end of line repair evaluation, a corner portion of a 30.5 centimeter by 30.5 centimeter OEM panel was sanded with 1200 grit sand paper for about 10 centimeter radius. A basecoat wedge was applied to the sanded portion so that the sanded corner of the panel had a dry film thickness of about 12.7 micrometer which reduced to about 2.5 micrometer dry film thickness at the edge of the sanded area. After flashing in an 82°C oven for 10 minutes, the clearcoats from Table 3 were then sprayed over the flashed basecoat to form a wedge of clearcoat composition having a dry film build of about 38.1 micrometer starting at the sanded corner of the panel to be less than about 2.5 micrometer about 1 centimeter past the sanded area. In the next step, butyl acetate was added to the clearcoats to reduce the solids of the clearcoats by 70%. A layer of the reduced clearcoat composition was applied to an area overlapping both the repair clearcoat composition and the OEM clearcoat composition. The repaired panels were then baked in a 90°C oven for 20 minutes. The baked panels were subject to light sanding in the bridging area with 2000-grit sanding paper, followed by 3 minutes of polishing with 3M® FINESSE-IT® Extrafine Polish (product number 06002). These panels were visually evaluated for haze in the repaired area versus the OEM area, and examined for the presence of haze or texture in the bridging area.

| TABLE 4 |
|-----------------|-----------------|-----------------|-----------------|
| Property Test   | End of Line Repair |
| Tukon Hardness  | 10 day humidity | Polishability/ Appearance | Bridge removability |
| Clearcoat Adhesion* and Appearance | Resistance | Appearance | removability |
| Clearcoat 1      | 2.7             | 100% and OK | Excellent | Excellent |
Comparative Clearcoat A | 1.2 | 100% but haze | Blistering | Too soft to polish
---|---|---|---|---
Comparative Clearcoat B | 2.5 | Fail and haze | Blistering | Haze | poor

*time after 10 day humidty*

[70] As Table 3 shows, Comparative Clearcoat A was too soft to polish, though it showed excellent clearcoat adhesion. Comparative Clearcoat B, showed acceptable hardness, however, at a cure temperature of 90°C, it had poor clearcoat adhesion and unacceptable 10 day humidity resistance. The end of line repairability was also unacceptable due to difficulty in removing the bridging line between the OEM and the repair areas, a result of poor clearcoat adhesion. Clearcoat 1 had acceptable properties in all tests.

[71] Common Clearcoat Soup 2 was prepared by mixing together the ingredients of Table 5 in the following order, with stirring.

[72]

<table>
<thead>
<tr>
<th>TABLE 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parts by weight</td>
</tr>
<tr>
<td>RESIMENE® CE-4514 melamine</td>
</tr>
<tr>
<td>DESMODUR® BL-3575 polyisocyanate</td>
</tr>
<tr>
<td>TINUVIN® 328 solution¹</td>
</tr>
<tr>
<td>HALS solution²</td>
</tr>
<tr>
<td>Flow Aid³</td>
</tr>
<tr>
<td>ethyl 3-ethoxy propionate</td>
</tr>
<tr>
<td>AROMATIC® 100 solvent</td>
</tr>
<tr>
<td>Total</td>
</tr>
</tbody>
</table>

1. 25% TINUVIN® 328 in AROMATIC® 100.
2. 28.6% TINUVIN® 928, 3.5% TINUVIN® 123 and 26.1% TINUVIN® 079 in AROMATIC® 100.
3. DISPARLON® L-1984 acrylic polymer, 50% in AROMATIC® 100 available from King Industries, Norwalk, Connecticut

[73] Prepartion of Clearcoat Examples 2-4 and Comparative Clearcoat Examples C, D and E.

[74] Clearcoat examples were prepared by mixing together the ingredients as shown in Table 6. All amounts in table 6 are in parts by weight.
1. Dodecyl benzene sulfonic acid salt of 2-amino-2-methyl-1-propanol supplied by King Industries, Norwalk, Connecticut, 33.6% in butanol.

About half a milliliter of each of the clearcoat compositions was poured onto individual OEM panels. Each of the applied films was then analyzed using an Attenuated Total Reflection Infrared (ATR-IR) spectrophotometer to determine if any free isocyanate was present by analyzing for a peak around 2270 cm\(^{-1}\). The panels

| TABLE 6 |
|-----------------|-----|-----|-----|-----|-----|-----|
|                | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Comparative Clearcoat E |     |     |     |     |     |
| Clearcoat 4     | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Clearcoat D     | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Comparative Clearcoat C |     |     |     |     |     |
| Clearcoat 3     | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Clearcoat 2     | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Clear Common Soup | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Polymer 1       | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Silane functional Polymer 1 | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Catalyst\(^1\)  | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Dodecylbenzene sulfonic acid | 6:6 | 10  | 0.32| 0.3 | 0.1 |
| Dibutyl tin dilaurate | 6:6 | 10  | 0.32| 0.3 | 0.1 |
were then placed in an oven set to 71°C. After 20 minutes in the oven, the panels were removed and the applied film was analyzed using ATR-IR for the presence of free isocyanate. The temperature of the oven was then increased between 5°C and 7°C and the panels were baked at the new temperature for 20 minutes each and reanalyzed by ATR-IR. This was repeated until a maximum oven temperature of 110°C was reached. Figure 1 shows the effect of baking temperatures on the isocyanate formation of Comparative Clearcoat C. Figure 2 shows the effect of baking temperatures on the isocyanate formation of Clearcoat 2. Figure 3 shows the effect of baking temperatures on the isocyanate formation of Comparative Clearcoat D. Figure 4 shows the effect of baking temperatures on the isocyanate formation of Clearcoat 3. Comparing Figure 1 (Comparative Clearcoat C) with Figure 2 (Clearcoat 2), readily shows that the presence of the silane functional polymer decreases the temperature needed to form the free isocyanate. A similar trend can be seen when comparing Figure 3 (Comparative Clearcoat D) with Figure 4 (Clearcoat 3). Note the differences in scale between each of Figures 1-4.

[77] Also analyzed using ATR-IR during the baking of the clearcoats was the relative amount of the isocyanate by integrating the area under the peak from 2331 cm⁻¹ to 2210 cm⁻¹, the relative amount of melamine by integrating the area under the peak from 1591 cm⁻¹ to 1533 cm⁻¹ and the relative amount of blocked isocyanate by integrating the area under the peak from 1533 cm⁻¹ to 1503 cm⁻¹. Since the blocked isocyanate and melamine were added at equivalent weights for all clearcoat compositions, it was possible to quantitatively follow the influence of the silane functional polymer on the isocyanate formation of the coating composition. Figures 5 and 6 show the effect of the baking temperature on the formation of free isocyanate groups on the clearcoat compositions. The analysis at different baking temperatures was conducted and the ratio of isocyanate and blocked isocyanate to melamine versus the bake temperature was plotted to give the graphs in Figures 5 and 6. Figure 5 shows a comparison of Comparative Clearcoat C (represented by the diamonds) and Clearcoat 2 (represented by the squares) and shows that the presence of the silane functional polymer can lower the curing temperature about 10°C. Figure 6 shows a comparison of Comparative Clearcoat D (represented by the diamonds) and Clearcoat 3 (represented by the squares) and shows that the presence of the silane functional polymer can lower the curing temperature of the isocyanate about 5 to 10°C.

[78] Preparation of Amine Blocked Catalyst for Waterborne Basecoat Examples

[79] The ingredients in Table 7 were mixed with stirring to form catalyst examples. All amounts in Table 7 are in parts by weight.
Comparative catalyst A is dodecylbenzene sulfonic acid blocked with AMP, and is commonly used as a catalyst in many acid-catalyzed coating compositions, while Catalyst Examples 1 and 2 used N-methyl morpholine and N,N-dimethyl isopropanol amine which are more volatile and less basic than AMP.

The blocked catalysts of Table 7 were each added to a waterborne white basecoat (product code 562S621011, available from DuPont Performance Coatings, Wilmington, DE) at 2 percent by weight. These three waterborne white basecoats were then sprayed to electrocoated and primed steel panels to obtain a dry film build of 23 to 28 micrometers (0.9 to 1.1 mil) under similar booth conditions described in previous sections. The sprayed panels were flashed in an 82°C oven for 10 minutes. After cooling to room temperature, Clearcoat 1 was then spray over each of these basecoats to obtain a dry film build in the range of from 46 to 51 micrometers (1.8-2.0 mil), and baked in a 90°C oven for 20 minutes. Table 8 shows the comparative Tukon hardness and humidity resistance of the different coatings.

### TABLE 7

<table>
<thead>
<tr>
<th>Ingredient</th>
<th>Catalyst Example 1</th>
<th>Catalyst Example 2</th>
<th>Comparative Catalyst A</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deionized water</td>
<td>5</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Dodecylbenzene sulfonic acid</td>
<td>4.1</td>
<td>4.1</td>
<td>4.1</td>
</tr>
<tr>
<td>AMP</td>
<td>0</td>
<td>0</td>
<td>0.9</td>
</tr>
<tr>
<td>N-methyl morpholine</td>
<td>0.97</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>N,N-dimethyl isopropanol amine</td>
<td>0</td>
<td>1.0</td>
<td>0</td>
</tr>
</tbody>
</table>

### TABLE 8

<table>
<thead>
<tr>
<th></th>
<th>Tukon Hardness</th>
<th>Humidity Resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control White Basecoat</td>
<td>1.2</td>
<td>Large Blisters</td>
</tr>
<tr>
<td>White Basecoat with</td>
<td>1.3</td>
<td>Large Blisters</td>
</tr>
<tr>
<td>Comparative Catalyst A</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Basecoat with</td>
<td>2.3</td>
<td>OK</td>
</tr>
<tr>
<td>Catalyst Example 1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>White Basecoat with</td>
<td>2.0</td>
<td>OK</td>
</tr>
<tr>
<td>Catalyst Example 2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Table 8 shows that when cured at relatively low temperatures, the control white basecoat/clearcoat and the comparative white basecoat/clearcoat using a comparative catalyst A have lower Tukon hardness and humidity resistance when compared to white basecoat/clearcoat compositions comprising weak amine catalysts. This result indicates incomplete curing of the control example and of the white basecoat/clearcoat with comparative catalyst A. The white basecoat/clearcoat with catalyst examples 1 and 2, showed higher Tukon hardness and acceptable humidity resistance even though the baking temperature was relatively low.
CLAIMS

What is claimed is:

1. A solventborne clearcoat composition comprises a film forming binder wherein the film forming binder comprises;
   a) blocked polyisocyanate;
   b) silane functional polymer or silane functional oligomer;
   c) optionally, melamine resin and/or a crosslinkable polymer;
   d) optionally, another crosslinkable polymer; and
wherein the solventborne clearcoat composition further comprises one or more crosslinking catalysts.

2. The solventborne clearcoat composition of claim 1 wherein the film forming binder consists essentially of in the range of from 5 to 30 percent by weight of blocked polyisocyanate; in the range of from 20 to 80 percent by weight of the silane functional polymer, in the range of from 0 to 30 percent by weight of melamine resin; in the range of from 0 to 40 percent by weight of another crosslinkable polymer; and wherein the solventborne coating composition further comprises in the range of from 0.5 to 4 percent by weight of crosslinking catalysts, wherein all percentages by weight are based on the total amount of film forming binder.

3. The solventborne coating composition of claim 1 wherein the blocked polyisocyanate is produced from a polyisocyanate selected from the group consisting of aliphatic diisocyanates, aliphatic polyisocyanates, homopolymers of aliphatic diisocyanates, homopolymers of aliphatic polyisocyanates, copolymers of aliphatic diisocyanates, copolymers of aliphatic polyisocyanates and a combination thereof.

4. The solventborne coating composition of claim 3 wherein the blocking agent of the blocked polyisocyanate is selected from the group consisting of pyrazole, alkyl pyrazoles, dialkyl pyrazoles, imidazoles, and pyridine.

5. The solventborne clearcoat composition of claim 4 wherein the blocking agent of the blocked polyisocyanate is a pyrazole compound having a structure according to the formula;
wherein each \( R^2 \) is an alkyl group having in the range of from 1 to 4 carbon atoms, an alkenyl group having in the range of from 2 to 4 carbon atoms, an aromatic group, or an ester group having 1 to 4 carbon atoms in the ester portion; and \( q \) is an integer from 0 to 3.

6. The solventborne clearcoat composition of claim 1 wherein the silane functional polymer is a copolymer produced from the polymerization of a monomer mixture comprising in the range of from 20 to 95 percent by weight of alkyl (meth)acrylates and in the range of from 5 to 80 percent by weight of silane functional ethylenically unsaturated monomers, wherein the percentages by weight are based on the total weight of monomers in the monomer mixture.

7. A method for the end of line repair of a defect of a dried and cured OEM coating composition on a substrate comprises the steps of:
   1) identifying an area to be repaired;
   2) optionally, removing the substrate from a manufacturing line;
   3) removing at least a portion of the coating composition around the area to be repaired;
   4) applying one or more layers of a basecoat composition to at least a portion of the area to be repaired;
   5) flashing the applied layer of basecoat composition to remove at least a portion of the solvent;
   6) applying one or more layers of a solventborne clearcoat composition to at least a portion of the applied basecoat composition;
   7) flashing the applied layer of solventborne clearcoat composition to remove at least a portion of the solvent;
   8) curing the applied layers of basecoat composition and solventborne clearcoat composition at a temperature in the range of from 80°C to 115°C; and
   9) optionally, returning the substrate to the manufacturing line;
wherein the basecoat composition comprises an amine blocked acid catalyst; and wherein the solventborne clearcoat composition comprises a film forming binder wherein the film forming binder comprises;
   a) a blocked polyisocyanate;
   b) a silane functional polymer or silane functional oligomer;
   c) optionally melamine resin;
   d) optionally another crosslinkable polymer; and

wherein the solventborne coating composition further comprises one or more crosslinking catalysts.


9. The method of claim 7 wherein the solventborne clearcoat composition comprises in the range of from 5 to 30 percent by weight of blocked polyisocyanate; in the range of from 20 to 80 percent by weight of the silane functional polymer, in the range of from 0 to 30 percent by weight of melamine resin; in the range of from 0 to 40 percent by weight of the crosslinkable polymer; and in the range of from 0.5 to 4 percent by weight of crosslinking catalysts, wherein all percentages by weight are based on the total amount of film-forming binder.

10. The method of claim 7 wherein the silane functional polymer is a copolymer produced from the polymerization of a monomer mixture comprising in the range of from 20 to 95 percent by weight of alkyl (meth)acrylates and in the range of from 5 to 80 percent by weight of silane functional ethylenically unsaturated monomers, wherein the percentages by weight are based on the total weight of monomers in the monomer mixture.

11. The method of claim 7 wherein the blocked polyisocyanate is produced from a polyisocyanate selected from the group consisting of aliphatic diisocyanates, aliphatic polyisocyanates, homopolymers of aliphatic diisocyanates, homopolymers of aliphatic polyisocyanates, copolymers of aliphatic
diisocyanates, copolymers of aliphatic polyisocyanates and a combination thereof.

12. The method of claim 7 wherein the basecoat composition is a waterborne basecoat composition.

13. The method of claim 12 wherein the waterborne basecoat composition comprises an acid catalyst that is blocked with a weak amine.

14. The method of claim 12 wherein the acid catalyst is dodecylbenzene sulfonic acid and the weak amine is selected from the group consisting of n-methyl morpholine, N,N-dimethyl isopropanol amine.

15. The method of claim 12 wherein the blocking agent of the blocked polyisocyanate is selected from the group consisting of pyrazole, alkyl pyrazoles, dialkyl pyrazoles, imidazoles, and pyridine.

16. The method of claim 7 wherein the blocking agent of the blocked polyisocyanate is a pyrazole compound having a structure according to the formula:

\[
\begin{array}{c}
\text{N} \\
\text{H} \\
\end{array}
\]

\[
\begin{array}{c}
\text{N} \\
\text{H} \\
\end{array}
\]

\[
(R^2)q
\]

wherein each \(R^2\) is an alkyl group having in the range of from 1 to 4 carbon atoms, an alkenyl group having in the range of from 2 to 4 carbon atoms, an aromatic group, or an ester group having 1 to 4 carbon atoms in the ester portion; and \(q\) is an integer from 0 to 3.

17. The method of claim 7 wherein the silane functional polymer or oligomer is produced from a monomer mixture comprising in the range of from 5 to 80 percent by weight of a silane functional ethylenically unsaturated monomer having a structure according to the formula;
wherein R is an alkyl group having in the range of from 1 to 4 carbon atoms, R1 is an alkyl group having in the range of from 1 to 4 carbon atoms and x is 0, 1 or 2, R3 is H or CH₃ and R4 is an optionally substituted alkyl group having in the range of from 1 to 10 carbon atoms that can be linear, branched, cycloaliphatic or a combination thereof.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - B60C 1/00 (2011.01)
USPC - 524/261

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC(8): B60C 1/00 (2011.01); USPC: 524/261

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

USPC: 524/261 590,839,840:427/372.2

Electronic database consulted during the international search (name of data base and, where practicable, search terms used)

Google Scholar, Google Patents, PubWEST (PGPB.USPT.EPAB.JPAB) (solvent, water, borne, dearcoat, block, polyisocyanate, silane, melamine, crosslink, pyrazole, imidazole, methacrylate, repair, flash, cure, sulfonic, add, catalyst, temperature, morpholine)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>US 2006/0047036 A1 (Lin) 02 Mar 2006 (02.03.2006) paragraphs [0023]-[0033], [0040]-[0044], [0048H0057], [0067], [0085]-[0087], [0110]</td>
<td>1-4, 6</td>
</tr>
</tbody>
</table>

Date of the actual completion of the international search
15 Aug 2011 (15.08.2011)

Date of mailing of the international search report
26 AUG 2011

Authorized officer:
Lee W. Young

Facsimile No. 814-293-3264

Form PCT/ISA/2 10 (second sheet) (July 2009)