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(54) Title: COATING COMPOSITIONS COMPRISING UREA AND MULTILAYER COATING SYSTEMS COMPRISING THE SAME

(57) Abstract: A liquid coating composition is provided, comprising (i) a film-forming compound; (ii) an aqueous medium; and (iii) a urea compound. Methods of using such a coating composition, and multilayer coating systems including such a coating composition are also disclosed.



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COATING COMPOSITIONS COMPRISING UREA AND MULTILAYER COATING SYSTEMS COMPRISING THE SAME

FIELD OF THE INVENTION

[0001] The present invention relates to liquid coating compositions that comprise a film-forming compound; an aqueous medium; and a urea compound. Methods of using the same and multilayer coating systems comprising the same are also within the scope of the present invention.

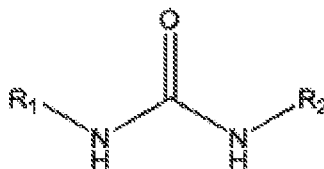
BACKGROUND OF THE INVENTION

[0002] Coating compositions are used in a wide variety of applications, including, for example, the automotive, appliance and industrial industries. Coatings are often used to provide decorative qualities and/or corrosion protection to the substrates over which they are applied. Such coatings typically have a largely defect-free surface, and in the case of automotive decorative finishes, also a very smooth surface. The automotive industry has particularly strict requirements as to the appearance of the coatings that are used.

[0003] Automotive coatings are typically applied by spray applicators and therefore have a high shear viscosity of less than 150 cp (centipoise) to allow the coating to flow through the spray applicator. If the coating composition is too viscous, a solvent, such as water or organic solvent, may be added to the coating composition to achieve the desired high shear viscosity. Addition of the solvent, however, while reducing the high shear viscosity may also reduce the total solids in the coating composition. As a result multiple passes of the spray gun and/or a slower pass or flow of coating as the substrate is sprayed may be needed to achieve the desired film build. Compositions having a desired high shear viscosity and solid content are sought.

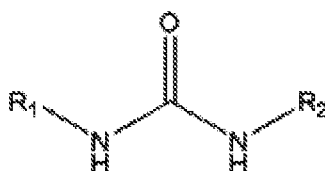
SUMMARY OF THE INVENTION

[0004] The present invention provides a liquid coating composition comprising, (i) a film-forming compound; (ii) an aqueous medium; and (iii) a urea compound having the structure:



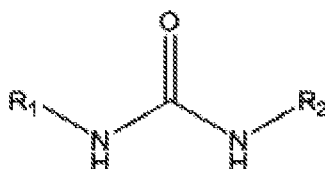
wherein R1 and R2 are independently H or an alkyl group.

[0005] The present invention also provides a method of increasing total solid content while maintaining or reducing the high shear viscosity of a liquid coating composition comprising: incorporating a urea compound into the coating composition, wherein the urea compound has the structure:



wherein R1 and R2 are independently H or an alkyl group.

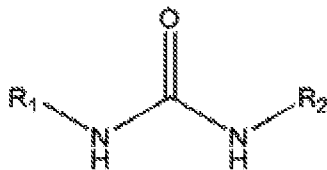
[0006] The present invention further provides a process for forming a multilayer coating on a substrate, the process comprising: forming a first basecoat layer over at least a portion of a substrate by depositing a first basecoat composition over at least a portion of the substrate, optionally, drying or curing the first basecoat layer; forming a second basecoat layer on at least a portion of the first basecoat layer by depositing a second basecoat composition, which can be the same or different from the first basecoat composition, directly onto at least a portion of the first basecoat layer, optionally, drying or curing the second basecoat layer; forming a clear coat layer on at least a portion of the second basecoat layer by depositing a clear coat composition directly onto at least a portion of the second basecoat layer; and curing any uncured coating layer, wherein the first basecoat layer and/or second basecoat layer comprise a urea compound having the structure:



wherein R1 and R2 are independently H or an alkyl group.

[0007] The present invention also provides a method of decreasing high shear viscosity of a liquid coating composition, wherein the total solid content of the

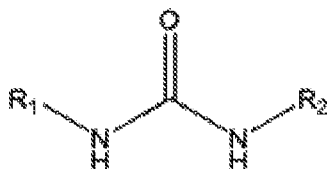
composition increases or does not decrease by more than 4% comprising:
incorporating a urea compound into the coating composition in an amount of 0.1 to 30 weight percent based on the total weight of solid content in the composition, wherein the urea compound has the structure:



wherein R1 and R2 are independently H or an alkyl group.

DETAILED DESCRIPTION OF THE INVENTION

[0008] The present invention is generally directed to liquid coating compositions comprising: (i) a film-forming compound, (ii) an aqueous medium and (iii) a urea compound having the structure:



wherein R1 and R2 are independently H or an alkyl group.

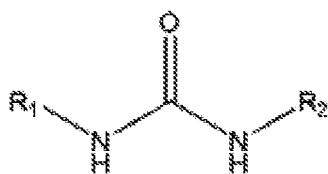
[0009] Any film-forming compound can be used according to the present invention. A "film-forming compound", "film-former", or like terms refers to a compound that can form a self-supporting continuous film on at least a horizontal surface of a substrate. For example, the film-forming compound can be a polymer or resin that can crosslink with itself and/or a crosslinking agent upon cure. Conventional film-forming compounds used in automotive OEM coating compositions, automotive refinish coating compositions, industrial coating compositions, architectural coating compositions, coil coating compositions, and aerospace coating compositions, for example, could all be used according to the present invention. Suitable non-limiting examples of film forming compounds include those made from, acrylic polymers, alkyd polymers, polyester polymers, polyurethane polymers, polyether polymers, polyepoxide polymers, silicon-containing polymers, and mixtures thereof. As noted above, the film forming compound can comprise a self-crosslinking compound and/or can comprise a compound that cures upon reaction with a crosslinker or curing agent. Suitable crosslinkers can be determined by one skilled in the art based upon the resin selected, and generally include aminoplasts, polyisocyanates, polyacids, carbodiimide,

anhydrides and mixtures thereof. A particular example of a film-former is a mixture of a polyurethane acrylic latex and a melamine crosslinker. "Film-forming compound" collectively refers to a resin and crosslinker in those systems in which cure is achieved by use of a crosslinker. According to the invention, the film forming compound may exclude urea in any form other than the urea described herein.

[0010] The coating compositions of the present invention can comprise 10 weight percent or greater film forming compound, with weight percent based on the total weight of the composition, such as 20 weight percent or greater, or 40 weight percent or greater. The amount of film forming compound does not include the urea compound, even if the urea reacts with the film forming components.

[0011] The present coating compositions also comprise an aqueous medium. An "aqueous medium" is a liquid medium that is 50 weight percent or greater of water, with weight percent based on non-solid content of the coating composition. The aqueous medium may comprise less than 50 weight percent of other solvents, either organic or inorganic; these solvents may be substantially fully miscible with or soluble in water. Suitable organic solvents include an ester, ketone, glycol ether, alcohol, hydrocarbon or mixtures thereof. Suitable ester solvents include alkyl acetates such as ethyl acetate, n-butyl acetate, n-hexyl acetate, and mixtures thereof. Examples of suitable ketone solvents include methyl ethyl ketone, methyl isobutyl ketone, and mixtures thereof. Examples of suitable hydrocarbon solvents include toluene, xylene, aromatic hydrocarbons such as those available from Exxon-Mobil Chemical Company under the SOLVESSO trade name, and aliphatic hydrocarbons such as hexane, heptanes, nonane, and those available from Exxon-Mobil Chemical Company under the ISOPAR and VARSOL trade names. The present coating compositions can comprise 20 weight percent or greater aqueous medium, such as 30 weight percent or greater or 40 weight percent or greater, with weight percent based on the total weight of the composition.

[0012] The present coating compositions also comprise a urea compound represented by Structure 1:



Structure 1

where R1 and R2 are independently H or an alkyl group. By "alkyl" is meant any carbon containing compound or residue thereof, typically having one to twelve carbons, including alkyl and aralkyl, cyclic or acyclic, linear or branched monovalent hydrocarbon groups. As used herein, "urea compound" and like terms refers to the monomeric form of urea or alkyl urea and not the oligomeric form or polymeric form of urea such as polyurea or polyurethane. It will be appreciated that when both R1 and R2 are H, structure 1 represents urea, and when R1 and R2 are both methyl, structure 1 represents dimethylurea, each of which are particularly suitable for use in the present compositions. The urea compound may be obtained in dry solid form and added to the liquid coating compositions. Alternatively, the urea compound can be incorporated in a liquid carrier, such as water, prior to adding to the liquid coating compositions. Such a solution can comprise a urea compound in the solution at an amount of 20 to 50 weight percent, or in an amount of 30 to 45 weight percent based on the total weight of the solution.

[0013] The urea compound can be present in coating compositions in an amount of 0.1 to 30 weight percent, based on the total solid weight of the composition, such as in an amount of 1 to 20, or in an amount of 2 to 12 weight percent. The urea compound can also be present in an amount of 0.1 weight percent or greater, based on the total solid weight in the coating composition, such as in an amount of 2 weight percent or greater. Further, the urea compound can be present in an amount of 30 weight percent or less, based on the total solid weight in the coating composition, such as in an amount of 12 weight percent or less. When a weight percent described herein is based on the total solid content of a coating composition, the calculation of the total solid content includes all non-volatile materials, e.g. solids, film-forming compounds, reactive agents, the urea compound, etc., but excludes any volatile solvents in the coating composition. The total solid content of a coating composition can be measured by the methods outlined in the examples. The urea compound can further be present in an amount of 1 weight percent or greater, based on the total weight of the water in the coating composition, such as in an amount of 5 weight percent or greater. When a weight percent described herein is based on the total weight of water, the calculation includes all of the water in the system, including water that comes in through the resin, any additives and the like, and does not include any other solvent. The urea compound maybe selected and incorporated in an amount to increase the solids content while still achieving the desired coating high shear viscosity.

[0014] The coating compositions of the present invention may optionally include additional materials such as fillers, colorants, waxes, extenders, rheology modifiers, adhesion promoters, pigments, dispersants, plasticizers, anti-oxidants, hindered amine light stabilizers, UV light absorbers and stabilizers, surfactants, flow control agents, thixotropic agents, fillers, organic cosolvents, abrasion resistant particles, catalysts, grind vehicles, and other customary auxiliaries that are known to those skilled in the art. "Colorant" is defined in U.S. Patent No. 8,614,286, at column 7, lines 5 to 23, which are incorporated by reference herein.

[0015] It is common practice in the coatings art to use water or other solvents to reduce the high shear viscosity of coating compositions for application. This is particularly true when using liquid coatings that will be spray applied. When diluted to a suitable high shear viscosity with water or other solvents, however, the coating compositions typically have a lower total solids content. This may affect the appearance and/or performance of the coating. For example, when applying the diluted coating to a substrate, multiple passes of the spray applicator may be necessary to achieve a desired film build (i.e. thickness), the line may need to be slowed down, and the like.

[0016] It has been surprisingly discovered that using a urea compound according to the present invention increases the total weight percent of solids in a coating composition while at the same time decreasing the high shear viscosity. This is in contrast to many reactive diluents known in the art, which increase solids but typically also significantly increase high shear viscosity. This is also in contrast to organic solvents, which typically decrease high shear viscosity but do not increase the solids content. Similarly, water is often used to reduce the high shear viscosity of a coating composition but will also decrease the total solids content. Use of a urea compound instead of water, therefore, to decrease the high shear viscosity of a coating composition will serve to increase the total solids content of the composition. Notably, the effect on high shear viscosity in the coating when using a urea compound is similar to that when an equal weight amount of water is used. The coating compositions of the present invention can have a higher total solids content than, and a high shear viscosity within plus or minus 20% of, a coating composition in which the urea compound has been replaced with an equal weight amount of water, such as a high shear viscosity within plus or minus 15% or plus or minus 10%. The present coatings can also have a higher total solids content than, and a high shear viscosity

within plus 20% of, a coating composition in which the urea compound is replaced with an equal weight amount of water, such as within 15%, within 10% or within 8%. The coating compositions of the present invention can have, for example, a high shear viscosity in the range of 40 cp to 150 cp, such as 80 cp to 120 cp. As used herein, "high shear viscosity" refers to viscosity as measured on a Brookfield model CAP-2000+ viscometer (BYK-Gardner GmbH, Geretsried, DE) using a #4 Spindle at a speed of 300 RPM and at 25°C.

[0017] Accordingly, the present invention further provides a method for using a urea compound in a liquid coating composition to increase total solids content in the coating while decreasing the high shear viscosity of the coating. The urea compound can be incorporated in an aqueous coating composition in an amount of 0.1 to 45 weight percent, or in an amount of 1 to 30 weight percent, or in an amount of 3 to 18 weight percent based on the total water content of the aqueous coating composition. According to the invention, for example, if a urea compound is used to decrease the high shear viscosity of the coating composition, the total solid content of the composition will increase, while the high shear viscosity of the composition will be within plus or minus 20% of the high shear viscosity if water were used in an equal weight amount to achieve a reduction in the coating composition high shear viscosity. It may be desired to replace water with a urea compound on a 1:1 weight ratio, where the weight of the urea compound is the amount of solid urea itself and not the weight of the solution comprising the urea compound, or it may be desired to add a urea compound and water in unequal amounts, such as more urea compound in relation to water or vice versa. This can be determined based on the needs of the user taking into consideration such things as the desired high shear viscosity, the desired solids content, the chemistry of the film forming component and the like.

[0018] The present invention also provides a method of decreasing high shear viscosity of a liquid coating composition, wherein the total solid content of the composition increases or does not decrease by more than 4%. The urea compound content can be incorporated into the coating composition in an amount of 0.1 to 30 weight percent, such as in an amount of 1 to 20 weight percent, or in an amount of 2 to 12 weight percent based on the total weight of solid content in the composition. According to the present invention, for example, if a urea compound is incorporated into a coating composition in a sufficient amount to decrease the high shear viscosity, while the total solid content of the coating composition can increase or not decrease

by more than 4%. Stated another way, a urea compound can be incorporated into the coating composition in an amount to decrease the high shear viscosity while the total solid content of the composition can increase or not decrease to less than 96% of the original total solid content. For example, if a coating composition has an initial total solid content of 50 weight percent, the addition of a urea compound can increase the total solid content to more than 50 weight percent or not decrease the total solid content to less than 48 weight percent.

[0019] The coating compositions of the present invention can be applied to any substrates known in the art. These substrates can be, for example, metallic or non-metallic. Metallic substrates include tin, steel, tin-plated steel, chromium passivated steel, galvanized steel, aluminum, aluminum foil, coiled steel or other coiled metal. Non-metallic substrates including polymeric, plastic, polyester, polyolefin, polyamide, cellulosic, polystyrene, polyacrylic, poly(ethylene naphthalate), polypropylene, polyethylene, nylon, EVOH, polylactic acid, other "green" polymeric substrates, poly(ethyleneterephthalate) ("PET"), polycarbonate, polycarbonate acrylobutadiene styrene ("PC/ABS"), polyamide, wood, veneer, wood composite, particle board, medium density fiberboard, cement, stone and the like. The substrate can be one that has been already treated in some manner, such as to impart visual and/or color effect, a protective pretreatment or other coating layer, and the like.

[0020] The coating compositions of the present invention can be applied by any means standard in the art, such as electrocoating, spraying, electrostatic spraying, dipping, rolling, brushing, and the like. As mentioned herein, the high shear viscosity of the coating compositions of the present invention can be adjusted to a desired high shear viscosity without negatively impacting the total solid content of the coating compositions. Accordingly, spray application is a particularly suitable method of application.

[0021] The coating compositions of the present invention can, for example, be used in the formation of multilayer coating systems, which may include two or more layers at least one of which may be deposited from any of the coating compositions described above. For example, multilayer coating systems may include a basecoat layer and a clear coat layer. The multilayer coating systems can further include a second basecoat layer and an optional electrodeposition coat layer. The coating compositions of the present invention are particularly suitable for use in a compact coating process. A "compact coating process" or "compact process" is one in which at least one curing

step has been eliminated from a standard automotive coating process; stated another way, one or more curing steps are combined in a compact coating process in that one or more coating layers may be deposited on a previous coating layer, which may optionally be dried but not cured, in a “wet-on-wet” application and the layers cured simultaneously. Often, a compact process will eliminate the use of, and need to cure, a primer-surfacer layer; in the compact process a standard primer-surfacer layer can be replaced with a first basecoat layer. Some compact coating processes apply two basecoat layers, also known as a first basecoat layer (B1) and a second basecoat layer (B2), to a substrate. The liquid coating compositions disclosed herein can be used as a basecoat composition that forms either or both the first basecoat layer and second basecoat layer.

[0022] The optional electrodeposition coating compositions of the multilayer coating systems may include conventional anionic or cationic electrodepositable coating compositions, such as epoxy or polyurethane-based coatings. Suitable electrodepositable coating compositions have been described in U.S. Pat. Nos. 4,933,056; 5,530,043; 5,760,107 and 5,820,987. The cured electrodeposited layer, if used, can have a dry-film thickness as high as 100 micrometers, such as 15 to 50 micrometers.

[0023] As noted above, when one or more basecoats are used in multilayer coating systems, they can be deposited from the present coating compositions. Other suitable basecoat compositions that may be used in multilayer coating systems of the present invention are discussed in U.S. Pat. Nos. 8,152,982 and 8,846,156. If two or more basecoats are used, the basecoats can be the same or different. “Different” can include two different coating compositions according to the present invention. After application to at least a portion of the substrate, the first basecoat composition can be dried at ambient or elevated temperatures such as by forced air, or thermally cured. “Dried”, “drying” and like terms, when used in reference to an application of the coating layers, refers to removal of at least some water and/or solvent from the coating composition at temperatures lower than those needed to cure the coating and includes, for example, processes such as flashing or dehydrating. For example, drying can include a “flash”, which is generally performed by exposing a coated substrate to ambient or slightly elevated temperatures (typically 40°C or lower) for a brief period of time (typically 30 seconds to 20 minutes) to remove some solvent(s) but not as much as in a dehydrating process, in which a coated substrate is exposed to

temperature (typically in the range of 40°C to 121°C) for a period of time sufficient to remove solvents but insufficient to cure the coated substrate, such as 1 to 10 minutes. By drying at “ambient” it is meant that at least a portion of the solvents, e.g. including water or organic solvents, in the coating compositions can be removed without the aid of heat or other energy, for example, without baking in an oven, use of forced air, or the like.

[0024] Similarly, if used, a second basecoat layer can be deposited on at least a portion of substrate coated with the first basecoat and the coated substrate subjected again to a drying step as described above. If the first basecoat was only dried, and not cured, then the two basecoat layers can be cured simultaneously at this time. It will be appreciated that one curing step can therefore be eliminated by the wet-on-wet application of the second basecoat over the uncured first basecoat and simultaneous curing of the two basecoats together. The dry-film thickness of the first and second basecoat layers (or, alternatively, a single basecoat layer where applicable) can be as high as 100 micrometers, but usually ranges from 1 to 50, such as from 5 to 30, or from 10 to 25 micrometers.

[0025] The multilayer coating systems can further comprise a clear coat layer. A clear coat layer will be understood as a coating that is substantially transparent. A clear coat can therefore have some degree of color, provided it does not make the clear coat opaque or otherwise affect, to any significant degree, the ability to see the underlying substrate. The clear coat layer can be formed from either one component (“1K”), or multi-component compositions such as two component (“2K”) or more. A 1K composition will be understood as referring to a composition wherein all the coating components are maintained in the same container after manufacture, during storage, etc., while a 2K or multi-component composition will have two or more components that are stored separately and mixed just prior to application. Clear coat compositions are known in the art for automotive applications. Such clear coat compositions are described in U.S. Pat. Nos. 4,650,718; 5,814,410; and 5,891,981. The multilayer coating systems of the present invention can include, for example, a clear coat layer deposited on at least a portion of the substrate coated with the one or more basecoat layers as described above. The clear coat layer can be applied to a basecoat layer and cured using any conventional means. It will be appreciated that the clear coat can be applied to a dried but uncured basecoat and the layers cured simultaneously, or the basecoat(s) can be cured prior to application of the clear coat.

Once applied and cured, the clear coat layer can have a dry-film thickness of 100 micrometers such as from 30 to 50 micrometers.

[0026] The multilayer coating systems of the present invention, which can comprise two layers including one or two basecoat layers and/or a clear coat layer, wherein at least one of the basecoat layers is formed from a coating composition of the present invention, can demonstrate equivalent or improved appearance, as measured by shortwave or longwave scanning with a Byk Wave-scan Dual machine, as compared to similar multilayer coating systems that do not use a urea compound. For example, such a multilayer coating system can exhibit an improvement in appearance of at least 0.5 units, such as 1.0 or more units, based on shortwave scanning, as compared to similar cured multilayer coating systems having the same components but lacking the urea compound. It is understood by those skilled in the art that the lower the shortwave and longwave numbers the better the overall appearance of the multilayer coating system. The shortwave and longwave appearance number are determined in accordance with a Byk Wave-scan Dual (BYK-Gardner GmbH, Geretsried, DE at standard temperature (25°C)).

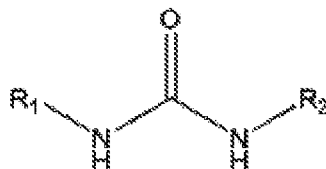
[0027] The present invention is also directed to a method for forming a multilayer coating system on a substrate, the method comprising: forming a first basecoat layer over at least a portion of a substrate by depositing a first basecoat composition over at least a portion of the substrate; optionally, drying or curing the first basecoat layer; optionally forming a second basecoat layer over at least a portion of the first basecoat layer by depositing a second basecoat composition directly onto at least a portion of the first basecoat layer; optionally, drying or curing the second basecoat layer; forming a clear coat layer on at least a portion of the outermost basecoat layer by depositing a clear coat composition directly onto at least a portion of the outermost basecoat layer; and curing any uncured coating layer simultaneously, wherein the first basecoat layer and/or second basecoat layer comprise a urea compound having Structure 1. The second basecoat composition, if used, can be the same or different from the first basecoat composition. It will be appreciated that the first and second basecoat, if used, can be cured individually, can be cured simultaneously, in both cases prior to forming the subsequent coating layer, or can be cured simultaneously with the clear coat. The process can further include the step of forming an electrodeposition coating layer by electrodepositing an electrodepositable coating composition on at least a portion of the substrate prior to the step of forming the first

basecoat layer. The electrodeposition coating layer can be dried or cured prior to forming the first basecoat layer.

[0028] As used herein, unless otherwise expressly specified, all numbers such as those expressing values, ranges, amounts or percentages may be read as if prefaced by the word "about", even if the term does not expressly appear. Any numerical range recited herein is intended to include all sub-ranges subsumed therein. Plural encompasses singular and vice versa. For example, while the invention has been described in terms of "a" film forming compound, "a" urea compound, "a" basecoat layer, and the like one or more of any of these items is within the scope of the invention. In addition, in this application, the use of "or" means "and/or" unless specifically stated otherwise, even though "and/or" may be explicitly used in certain instances. Also, as used herein, the term "polymer" is meant to refer to prepolymers, oligomers and both homopolymers and copolymers; the prefix "poly" refers to two or more. When ranges are given, any endpoints of those ranges and/or numbers within those ranges can be combined with the scope of the present invention. "Including", "such as", "for example" and like terms means "including/such as/for example but not limited to".

[0029] The present invention can be defined by the following clauses.

1. A liquid coating composition comprising:
 - (i) a film-forming compound;
 - (ii) an aqueous medium; and
 - (iii) a urea compound having the structure:



wherein R1 and R2 are independently H or an alkyl group.

[0030] 2. The composition of clause 1, wherein the coating composition has a higher total solids content than and a high shear viscosity within plus or minus 20% of a coating composition in which the urea compound has been replaced with an equal weight amount of water.

[0031] 3. The composition of clause 2, wherein the high shear viscosity is within plus or minus 10%.

[0032] 4. The composition of claim 2, wherein the high shear viscosity is within plus 10%.

[0033] 5. The composition of any of clauses 1-4, wherein R1 and R2 are both hydrogen.

[0034] 6. The composition of any of clauses 1-4, wherein the R1 and R2 are both methyl.

[0035] 7. The composition of any of clauses 1-6, wherein the urea compound is present in an amount of 0.1 to 30 weight percent based on the total solid weight of the composition.

[0036] 8. The composition of any of clauses 1-7, wherein the urea compound is present in an amount of 1 to 20 weight percent based on the total solid weight of the composition.

[0037] 9. The composition of any of clauses 1-8, wherein the urea compound is present in an amount of 2 to 12 weight percent based on the total solid weight of the composition.

[0038] 10. The composition of any of clauses 1-9, wherein the coating composition has a higher solids content and a lower high shear viscosity as compared to the same composition in which the urea has been removed.

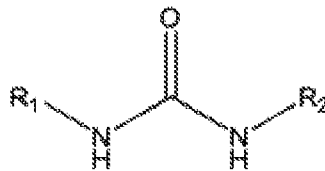
[0039] 11. The composition of any of clauses 1-10, wherein the composition has a high shear viscosity of 40 cp to 150 cp as measured with a Brookfield viscometer #4 spindle at a speed of 300 RPM, and at 25°C.

[0040] 12. A method for coating a substrate, comprising:

applying to at least a portion of the substrate the liquid coating composition of any of clauses 1-11.

[0041] 13. A method of increasing total solid content while maintaining or reducing the high shear viscosity of a liquid coating composition comprising:

incorporating a urea compound into the coating composition, wherein the urea compound has the structure:



wherein R1 and R2 are independently H or an alkyl group.

[0042] 14. The method of clause 13, wherein the urea compound is incorporated in an amount of 0.1 to 45 weight percent based on the total water content of the liquid coating composition.

[0043] 15. The method of clause 14, wherein the urea compound is incorporated in an amount of 1 to 30 weight percent based on the total water content of the liquid coating composition.

[0044] 16. A process for forming a multilayer coating system on a substrate, the process comprising:

forming a first basecoat layer over at least a portion of a substrate by depositing a first basecoat composition over at least a portion of the substrate;

optionally, drying or curing the first basecoat layer;

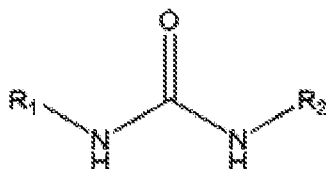
forming a second basecoat layer on at least a portion of the first basecoat layer by depositing a second basecoat composition, which is the same or different from the first basecoat composition, directly onto at least a portion of the first basecoat layer;

optionally, drying or curing the second basecoat layer;

forming a clear coat layer on at least a portion of the second basecoat layer by depositing a clear coat composition directly onto at least a portion of the second basecoat layer; and

curing any uncured coating layer,

wherein the first basecoat layer and/or second basecoat layer comprise a urea compound having the structure:



wherein R1 and R2 are independently H or an alkyl group.

[0045] 17. The process of clause 16, further comprising forming an electrodeposition coating layer by electrodepositing an electrodepositable coating composition on at least a portion of the substrate prior to the step of forming the first basecoat layer.

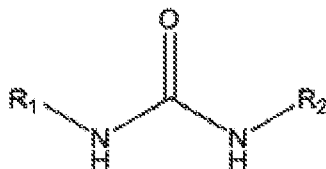
[0046] 18. The process of any of clauses 16 or 17, wherein second basecoat composition is different from the first basecoat composition.

[0047] 19. The process of any of clauses 16-18, wherein the second basecoat composition comprises the urea compound.

[0048] 20. The process of any of clauses 16-19, wherein the first and second basecoat layers are not cured prior to the forming of a subsequent coating layer and the first and second basecoat layers and the clear coat layer are cured simultaneously.

[0049] 21. A method of decreasing high shear viscosity of a liquid coating composition, wherein the total solid content of the composition increases or does not decrease by more than 4% comprising:

incorporating a urea compound into the coating composition in an amount of 0.1 to 30 weight percent based on the total weight of solid content in the composition, wherein the urea compound has the structure:



wherein R1 and R2 are independently H or an alkyl group.

[0050] 22. The method of clause 21, wherein the urea compound is incorporated in an amount of 2 to 12 weight percent based on the total weight of solid content in the composition.

EXAMPLES

[0051] The following examples are provided for illustrative purposes and should not be construed as limiting the invention in any way.

Example 1

[0052] A white basecoat composition was prepared according to Example 1 described in US 8,846,156 B2, which is incorporated in pertinent part herein, and had 22 weight percent resin solids, 30 weight percent pigment solids, 54 weight percent total solids, 8 weight percent organic solvent and 38 weight percent water, with all weight percents based on the total weight of the composition. This basecoat was used as a control.

[0053] In Examples 2 – 9, urea or water was incorporated in the control basecoat composition (Example 1) in amounts shown below in Table 1. The urea compound, added as a solid, or the water was added to the control basecoat composition and stirred for at least ninety (90) minutes.

Examples 2 – 9

Table 1

Components	Parts by Weight Component								
	Example 1	Example 2	Example 3	Example 4	Example 5	Example 6	Example 7	Example 8	Example 9
Control Basecoat	100	100	100	100	100	100	100	100	100
Additional Water	-	-	0.5	-	1.0	-	2.0	-	3.0
Urea ¹	-	0.5	-	1.0	-	2.0	-	3.0	-
Total	100	100.5	100.5	101.0	101.0	102.0	102.0	103.0	103.0
% Urea Based on Total Water Content ²	0.0	1.3	0.0	2.6	0.0	5.3	0.0	7.9	0.0

¹Urea, ACS certified, commercially available from Fisher Scientific.

² The total water content was based on the water content in the entire basecoat composition including, for example, the water content of the resin but did not include any other solvents.

[0054] The resulting basecoat compositions were measured for total solids and high shear viscosity; results are given in Table 2.

Table 2

Solids and Viscosity Data						
Example	Basecoat % Urea Level³	Grams Added Urea to 100g Paint	Basecoat % Additional Water Level⁴	Grams Added of Additional Water on 100g Paint	% Total Solids⁵	Viscosity⁶
1 (Control)	0.0	0.0	0.0	0.0	53.9	118
2	0.9	0.5	0.0	0.0	54.9	116
3	0.0	0.0	1.0	0.5	52.5	111
4	1.8	1.0	0.0	0.0	55.0	110
5	0.0	0.0	1.9	1.0	51.9	105
6	3.6	2.0	0.0	0.0	55.4	101
7	0.0	0.0	3.9	2.0	51.3	93
8	5.4	3.0	0.0	0.0	56.0	93
9	0.0	0.0	6.0	3.0	50.4	83

³Basecoat % Urea Level is defined as the ratio of grams of urea added as a percentage of the total grams of non-volatile materials (i.e. solid content) in the basecoat multiplied by one hundred.

⁴Basecoat % Additional Water Level is defined as the ratio of grams of additional water added as a percentage of the total grams of non-volatile materials (i.e. solid content) in the basecoat multiplied by one hundred.

⁵Total solids measurements were collected using an Excellence Plus HX204 Moisture Analyzer instrument (Mettler-Toledo, Columbus OH). A drying temperature of 110°C was used in all cases to ensure complete film dehydration. The instrument was operated at 25°C. Determination of the end point for the dehydration process, appropriate quantities of material measured and data collection via instrument automation, as well as standard practices and procedures, were carried out as outlined in the Excellence Plus HX204 Moisture Analyzer Operating Instructions.

⁶High shear viscosity data was collected using a CAP2000+ Viscometer (BYK-Gardner GmbH, Geretsried, DE). Measurements were taken using a #4 Spindle at 300 RPM at 25°C. Standard practices and procedures were carried out as outlined in the Byk-Gardner CAP2000+ Operating Instructions Manual No. M02-313.

[0055] Examples 2, 4, 6 and 8, demonstrate that urea can be used to decrease the high shear viscosity of a basecoat composition while increasing the solids content of a basecoat. In Examples 3, 5, 7 and 9, in contrast, while water served to reduce the high shear viscosity of the basecoat, the total solids content of the composition also decreased. Notably, when comparing the total solids and high shear viscosity when urea was used versus an equal weight of water the high shear viscosity of the present compositions (Examples 2, 4, 6 and 8) was within approximately 12% of the compositions comprising water instead (Examples 3, 5, 7 and 9). Thus, a high shear

viscosity that was still suitable for spray application was achieved, as was an increase in the total solids.

Example 10

[0056] A gray basecoat composition was prepared according to Example 8 described in US 8,846,156 B2, which is incorporated in pertinent part herein, and had 29 weight percent resin solids, 15 weight percent pigment solids, 46 weight percent total solids, 12 weight percent organic solvent and 42 weight percent water, with all weight percents based on the total weight of the composition. This basecoat was used as a control.

In Examples 11 – 18, urea or additional water, was incorporated in the control basecoat composition (Example 10) in amounts shown below in Table 3 directly to the control basecoat composition (Example 10) and stirred for at least ninety (90) minutes. The urea compound was added as a solution made by combining the amount of urea and water indicated and mixing as a solution for ninety (90) minutes.

Examples 11 – 18

Table 3

	Parts by Weight Component								
Components	Example 10 (Control)	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16	Example 17	Example 18
Grey Basecoat	100	100	100	100	100	100	100	100	100
Additional Water	-	0.6	1.1	1.2	2.2	2.4	4.4	3.7	6.7
Urea	-	0.5	-	1.0	-	2.0	-	3.0	-
Total	100	101.1	101.1	102.2	102.2	104.4	104.4	106.7	106.7
% Urea Based on Total Water Content ⁷	0.0	1.2	0.0	2.3	0.0	4.5	0.0	6.6	0.0

⁷ The total water content was based on the water content in the entire basecoat composition including, for example, the water content of the resin but did not include any other solvents.

[0057] The resulting basecoat compositions were measured for total solids and high shear viscosity; results are given in Table 4.

Table 4

Solids and Viscosity Data						
Example	Basecoat % Urea Level⁸	Grams Added Urea to 100g Paint	Basecoat % Additional Water Level⁹	Grams Added of Additional Water on 100g Paint	% Total Solids¹⁰	Viscosity¹¹
10 (Control)	0.0	0.0	0.0	0.0	45.3	79
11	1.1	0.5	1.4	0.6	44.7	77
12	0.0	0.0	2.5	1.1	45.0	71
13	2.2	1.0	2.7	1.2	44.7	65
14	0.0	0.0	5.0	2.2	44.3	62
15	4.5	2.0	5.6	2.4	44.0	50
16	0.0	0.0	10.6	4.4	41.8	50
17	6.7	3.0	8.2	3.7	44.5	42
18	0.0	0.0	16.3	6.7	40.9	40

⁸Basecoat % Urea Level is defined as the ratio of grams of urea added as a percentage of the total grams of non-volatile materials (i.e. solid content) in the basecoat multiplied by one hundred.

⁹Basecoat % Additional Water Level is defined as the ratio of grams of additional water added as a percentage of the total grams of non-volatile materials (i.e. solid content) in the basecoat multiplied by one hundred.

¹⁰Total solids measurements were collected using an Excellence Plus HX204 Moisture Analyzer instrument (Mettler-Toledo, Columbus OH). A drying temperature of 110°C was used in all cases to ensure complete film dehydration. The instrument was operated at 25°C. Determination of the end point for the dehydration process, appropriate quantities of material measured and data collection via instrument automation, as well as standard practices and procedures, were carried out as outlined in the Excellence Plus HX204 Moisture Analyzer Operating Instructions.

¹¹High shear viscosity data was collected using a CAP2000+ Viscometer (BYK-Gardner GmbH, Geretsried, DE). Measurements were taken using a #4 Spindle at 300 RPM at 25°C. Standard practices and procedures were carried out as outlined in the Byk-Gardner CAP2000+ Operating Instructions Manual No. M02-313.

[0058] As demonstrated by Examples 13, 15 and 17, addition of the urea solution increased the total solid content of the basecoat composition while the high shear viscosity decreased as compared to the control. Example 11 showed a slight decrease in percent total solids when urea was added to the control basecoat composition. This decrease in percent total solids was within the margin of experimental error. By comparison, in Examples 12, 14, 16 and 18, as the amount of additional water was increased in the basecoat composition, the total solid content and the high shear viscosity decreased as compared to the control basecoat composition.

Examples 19-20**Table 5**

Components	Parts by Weight	
	Component	
	Example 19	Example 20
Example 1	100	100
Additional Water	1.7	1
Urea	0	0.7
Total	101.7	101.7
% Urea Based on Total Water Content ¹²	0.0	1.8

¹² The total water content was based on the water content in the entire basecoat composition including, for example, the water content of the resin but did not include any other solvents.

[0059] In the description below, Base1 refers to the gray basecoat of Example 10 and Base2 refers to the white basecoat of Example 1. Either a urea solution or additional water was added to Base2 as indicated in the above table. The urea solution was prepared by mixing the indicated amount of water and urea for ninety (90) minutes.

[0060] Each Base1 and Base2 was spray applied using a Compuspray Automatic Test Panel Machine (Spraymaiton, Inc.) equipped with a 95AR spraygun (Binks, Inc.) at 60 PSI using a 10 inch fan patten, 2 inch index distance, 6 inch initial index position up from bottom, and 10 strokes per coat. Both Base1 and Base 2 were spray applied in an environment controlled to 70-75° F. (21-24° C.) and 50-60% relative humidity onto 4 inch by 12 inch (10 cm by 30 cm) steel panels that were coated with cured 6060CZ electrocoat commercially available from PPG Industries, Inc. Base1 was applied in one coat and then flashed at ambient temperature for 5 minutes. Base2 was then applied in two coats, without a flash between coats, and then flashed at ambient temperature for 5 minutes and then dehydrated for 5 minutes at 185° F. (85° C.). The film thicknesses of Base1 and Base2 were approximately 0.6 mils (15 microns) and 0.8 mils (20 microns), respectively. Dry film thickness measurements were made using a Feritscope FMP30 (Fischer, Windsor T).

[0061] TKAPO1000, a 2K clear coat composition commercially available from PPG Industries, Inc., was then applied over the coated Base1/Base2 panels in two coats without a flash between coats. The clear coated panels were allowed to flash for 10 minutes at ambient conditions and baked for 30 minutes at 285° F. (140° C.). The clear coat had a dry film thickness of approximately 1.8 mils (45 microns).

[0062] Appearance was measured using a Byk Wave-scan Dual instrument (BYK-Gardner GmbH, Geretsried, DE). Longwave, shortwave, and DOI (GM) values were taken and the average of three measurements reported in Table 6 below. All measurements were taken at standard temperatures (25°C). Lower BYK Wave-scan values of longwave and shortwave are more desirable; higher values of DOI(GM) and total solids are more desirable.

Table 6

Horizontal Panels – 140°C Cure – Appearance and Solids Values									
B1	B2					Total Film Stack			
Example	Example	% B2 Urea Level ¹³	Water Level ¹⁴	Grams Added Urea to 100g Paint	Grams Added of Additional Water to 100g Paint	% Total Solids	Longwave	Shortwave	DOI (GM)
10	1 (Control)	0.0	0.0	0.0	0.0	52	9	27.7	81.9
10	19	0.0	3.3	0.0	1.7	51.2	6.6	24.3	82.6
10	20	1.3	2.0	0.7	1.0	51.6	5.6	19.4	87.4

¹³% B2 Urea Level is defined as the ratio of grams of urea added as a percentage of the total grams of non-volatile materials (i.e. solid content) in the white B2 basecoat multiplied by one hundred.

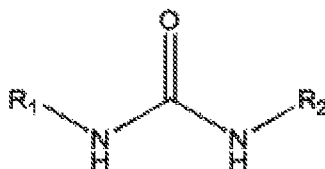
¹⁴% B2 Additional Water Level is defined as the ratio of grams of water added as a percentage of the total grams of non-volatile materials (i.e. solid content) in the white B2 basecoat multiplied by one hundred.

[0063] The solids and appearance data for Examples 1, 19 and 20 demonstrate the benefit of using a urea compound in at least one basecoat composition on the appearance of cured multilayer coating system. While lower longwave and shortwave numbers and higher DOI numbers were achieved with either additional water (Example 19) or urea (Example 20) as compared to the control, overall better appearance and higher solids can be achieved when using a urea solution as compared to an equal weight amount of water.

[0064] Whereas particular embodiments and aspects of this invention have been described above for purposes of illustration, it will be evident to those skilled in the art that numerous variations of the details of the present invention may be made without departing from the invention as defined in the appended claims.

We claim:

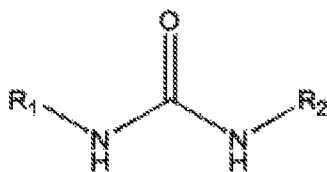
1. A liquid coating composition comprising:
 - (i) a film-forming compound;
 - (ii) an aqueous medium; and
 - (iii) a urea compound having the structure:



wherein R1 and R2 are independently H or an alkyl group.

2. The composition of claim 1, wherein the coating composition has a higher total solids content than and a high shear viscosity within plus or minus 20% of a coating composition in which the urea compound has been replaced with an equal weight amount of water.
3. The composition of claim 2, wherein the high shear viscosity is within plus or minus 10%.
4. The composition of claim 2, wherein the high shear viscosity is within plus 10%.
5. The composition of claim 1, wherein R1 and R2 are both hydrogen.
6. The composition of claim 1, wherein the R1 and R2 are both methyl.
7. The composition of claim 1, wherein the urea compound is present in an amount of 0.1 to 30 weight percent based on the total solid weight of the composition.
8. The composition of claim 1, wherein the urea compound is present in an amount of 1 to 20 weight percent based on the total solid weight of the composition.

9. The composition of claim 1, wherein the urea compound is present in an amount of 2 to 12 weight percent based on the total solid weight of the composition.
10. The composition of claim 1, wherein the coating composition has a higher solids content and a lower high shear viscosity as compared to the same composition in which the urea has been removed.
11. The composition of claim 1, wherein the composition has a high shear viscosity of 40 cp to 150 cp as measured with a Brookfield viscometer #4 spindle at a speed of 300 RPM, and at 25°C.
12. A method for coating a substrate, comprising:
applying to at least a portion of the substrate the liquid coating composition of claim 1.
13. A method of increasing total solid content while maintaining or reducing the high shear viscosity of a liquid coating composition comprising:
incorporating a urea compound into the coating composition, wherein the urea compound has the structure:



wherein R1 and R2 are independently H or an alkyl group.

14. The method of claim 13, wherein the urea compound is incorporated in an amount of 0.1 to 45 weight percent based on the total water content of the liquid coating composition.
15. The method of Claim 14, wherein the urea compound is incorporated in an amount of 1 to 30 weight percent based on the total water content of the liquid coating composition.
16. A process for forming a multilayer coating system on a substrate, the process comprising:

forming a first basecoat layer over at least a portion of a substrate by depositing a first basecoat composition over at least a portion of the substrate;

optionally, drying or curing the first basecoat layer;

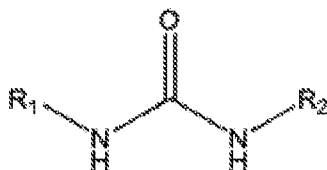
forming a second basecoat layer on at least a portion of the first basecoat layer by depositing a second basecoat composition, which is the same or different from the first basecoat composition, directly onto at least a portion of the first basecoat layer;

optionally, drying or curing the second basecoat layer;

forming a clear coat layer on at least a portion of the second basecoat layer by depositing a clear coat composition directly onto at least a portion of the second basecoat layer; and

curing any uncured coating layer,

wherein the first basecoat layer and/or second basecoat layer comprise a urea compound having the structure:



wherein R1 and R2 are independently H or an alkyl group.

17. The process of claim 16, further comprising forming an electrodeposition coating layer by electrodepositing an electrodepositable coating composition on at least a portion of the substrate prior to the step of forming the first basecoat layer.

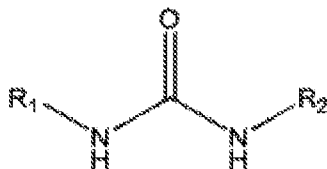
18. The process of claim 16, wherein second basecoat composition is different from the first basecoat composition.

19. The process of claim 16, wherein the second basecoat composition comprises the urea compound.

20. The process of claim 16, wherein the first and second basecoat layers are not cured prior to the forming of a subsequent coating layer and the first and second basecoat layers and the clear coat layer are cured simultaneously.

21. A method of decreasing high shear viscosity of a liquid coating composition, wherein the total solid content of the composition increases or does not decrease by more than 4% comprising:

incorporating a urea compound into the coating composition in an amount of 0.1 to 30 weight percent based on the total weight of solid content in the composition, wherein the urea compound has the structure:



wherein R1 and R2 are independently H or an alkyl group.

22. The method of claim 21, wherein the urea compound is incorporated in an amount of 2 to 12 weight percent based on the total weight of solid content in the composition.

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2015/021213

A. CLASSIFICATION OF SUBJECT MATTER

INV. C08K5/21 C09D175/00 B05D7/00 C09D7/12
ADD.

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)

C08K C09D B05D

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

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

EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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X	WO 95/26378 A1 (HENKEL CORP [US]) 5 October 1995 (1995-10-05) table 2 ----- -/-	1-22



Further documents are listed in the continuation of Box C.



See patent family annex.

* Special categories of cited documents :

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"&" document member of the same patent family

Date of the actual completion of the international search

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Lanz, Sandra

INTERNATIONAL SEARCH REPORT

International application No
PCT/US2015/021213

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
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