Summary

The present disclosure may relate to a method for enhancing the abrasion resistance (and durability) of a coating comprising acid-sintered silica nanoparticles coated onto a substrate, the method comprising the step of applying a primer coating (composition) comprising an organofunctional silane to the substrate prior to the step of applying the coating comprising acid-sintered silica nanoparticles to said substrate. In one aspect, there is provided a method for enhancing the abrasion resistance of a coating comprising acid-sintered silica nanoparticles coated onto a substrate, the method comprising ~~the step of~~ applying a primer coating comprising an organofunctional silane to said substrate prior to the ~~step of~~ applying of said coating comprising acid-sintered silica nanoparticles to said substrate, with the exception that the organofunctional silane is different from beta-aminoethyl-gamma-aminopropyltrimethoxysilane, wherein the organofunctional silane is chosen from epoxy silanes, amino silanes, acryloyloxy silanes, (meth)acryloyloxy silanes, alkoxy silanes, and any combination or mixture thereof.

The present disclosure may also be directed to a coating assembly comprising a substrate and a silica nanoparticle coating comprising acid-sintered silica nanoparticles thereon, wherein the coating assembly further comprises a primer coating comprising an organofunctional silane in-between the substrate and the silica nanoparticle coating comprising acid-sintered nanoparticles. In another aspect, there is provided a coating assembly comprising a substrate and a silica nanoparticle coating comprising acid-sintered silica nanoparticles thereon, wherein said coating assembly further comprises a primer coating comprising an organofunctional silane in-between said substrate and said silica nanoparticle coating comprising acid-sintered nanoparticles, with the exception that the organofunctional silane is different from beta-aminoethyl-gamma-aminopropyltrimethoxysilane, wherein the organofunctional silane is chosen from epoxy silanes, amino silanes, acryloyloxy silanes, (meth)acryloyloxy silanes, alkoxy silanes, and any combination or mixture thereof.

According to still another aspect, there is provided a coated article comprising a support and a coating assembly as described above thereon.

The present disclosure may also be directed to the use of a primer coating comprising an organofunctional silane for imparting abrasion resistance and/or durability to a silica nanoparticle coating comprising acid-sintered silica nanoparticles coated onto a substrate. In yet another aspect, there is provided use of a primer coating comprising an organofunctional silane for imparting abrasion resistance and/or UV-stability and/or durability to a silica nanoparticle coating comprising acid-sintered silica nanoparticles coated onto a substrate, with the exception that the organofunctional silane is different from beta-aminoethyl-gamma-aminopropyltrimethoxysilane, wherein the organofunctional silane is chosen from epoxy silanes, amino silanes, acryloyloxy silanes, (meth)acryloyloxy silanes, alkoxy silanes, and any combination or mixture thereof.

Detailed description

According to one aspect, the present disclosure relates to a method for enhancing the abrasion resistance (and durability) of a coating comprising acid-sintered silica nanoparticles coated onto a substrate, the method comprising the step of applying a primer coating (composition) comprising an organofunctional silane to the substrate prior to the step of applying the coating comprising acid-sintered silica nanoparticles to the substrate.

According to another aspect, the present disclosure relates to a method for enhancing the abrasion resistance (and durability) of a silica nanoparticle coating comprising acid-sintered silica nanoparticles coated onto a substrate, the method comprising the step of applying a primer coating comprising an organofunctional silane in-between the substrate and the coating comprising acid-sintered silica nanoparticles.

Suitable primer coating compositions for use herein comprise an organofunctional silane. In the context of the present disclosure, the expression "organofunctional silane" is meant to refer to a silane that comprises at least one organic ligand that possesses reactive chemical functionality. Suitable organofunctional silanes for use herein may commonly be referred to as silane coupling agents or silane adhesion promoters by those skilled in the art.

CLAIMS

1. A method for enhancing the abrasion resistance of a coating comprising acid-sintered silica nanoparticles coated onto a substrate, the method comprising ~~the step of~~ applying a primer coating comprising an organofunctional silane to said substrate prior to the ~~step of~~ applying of said coating comprising acid-sintered silica nanoparticles to said substrate, with the exception that the organofunctional silane is different from beta-aminoethyl-gamma-aminopropyltrimethoxysilane, wherein the organofunctional silane is chosen from epoxy silanes, amino silanes, acryloyloxy silanes, (meth)acryloyloxy silanes, alkoxy silanes, and any combination or mixture thereof.

2. A method according to claim 1, comprising ~~the steps of~~:
   a) contacting at least part of the surface of the substrate with a primer coating composition comprising ~~an~~ the organofunctional silane;
   b) drying, and optionally curing, said primer coating composition so as to form a primed surface;
   c) contacting said primed surface with a silica nanoparticle coating composition comprising an aqueous dispersion of silica nanoparticles preferably having an average particle diameter of less than 150 nanometers, said aqueous dispersion having a pH of less than 5; and
   d) drying said silica nanoparticle coating composition so as to provide a coating comprising acid-sintered silica nanoparticles onto said substrate.

3. A method according to claim 2, wherein said silica nanoparticle coating composition comprises:
   a) an aqueous dispersion of a mixture of silica nanoparticles having an average particle diameter of 40 nanometers or less and silica nanoparticles having an average particle diameter greater than 40 nanometers, and
   b) an acid having a pKa of less than 5.

4. A method according to claim 2, wherein said silica nanoparticle coating composition comprises:
   a) an aqueous dispersion of a mixture of acicular silica nanoparticles and spherical silica nanoparticles, wherein the spherical silica nanoparticles preferably have an average particle diameter of 100 nanometers or less; and
   b) an acid having a pKa of less than 5.

5. A method according to claim 2, wherein said silica nanoparticle coating composition comprises:

a) an aqueous dispersion of core-shell particles, each core-shell particle comprising a polymer core surrounded by a shell consisting essentially of silica nanoparticles disposed on said polymer core, said aqueous dispersion having a pH of less than 5, and

b) an acid having a pKa of less than 5.

6. A method according to any of the preceding claims, wherein the substrate comprises a material selected from the group consisting of polymeric materials, glass, ceramic, organic and inorganic composite material, metal, and any combinations thereof.

7. A method according to claim 6, wherein the substrate comprises an organic polymeric material, preferably selected from the group consisting of poly(meth)acrylates, polyurethanes, polyesters, polycarbonates, polyolefins, and any combinations or mixtures thereof; more preferably the substrate comprises polymethylmethacrylate.

8. A method according to any of the preceding claims, wherein the organofunctional silane ~~is selected from the group consisting of epoxy-silanes, amino-silanes, (meth)acryloyloxy silanes, alkoxy-silanes, and any combinations or mixtures thereof~~has the following chemical formula:

$$(R^1O)_m\text{-}Si\text{-}[(CH_2)_n\text{-}Y]_{4-m},$$

wherein

R^1 is a $(C_1\text{-}C_6)$alkyl,

m is 1 to 3,

n is 0 to 12,

Y is chosen from alkoxy, epoxycyclohexyl, glycidyl, glycidyloxy, acryloyloxy, (meth)acryloyloxy, $\text{-NH-CH}_2\text{CH}_2\text{-NR}^2\text{R}^3$, $\text{-NR}^2\text{R}^3$, and

R^2 and R^3 are each independently chosen from H, alkyl, phenyl, benzyl, cyclopentyl, and cyclohexyl.

9. A method according to any of the preceding claims, wherein the organofunctional silane is selected from the group consisting of 2-(3,4-epoxycyclohexyl) ethyltrimethoxysilane; (3-glycidoxypropyl) trimethoxysilane; 3-aminopropyltrimethoxysilane;3-(2-aminoethylamino) propyltrimethoxysilane; tetraethoxysilane; 3-(acryloyloxy) propyl trimethoxysilane; 3-(methacryloyloxy) propyl trimethoxysilane; and any combinations or mixtures thereof.

10. A method according to any of the preceding claims, wherein the primer coating composition is free of silica particles, in particular free of silica nanoparticles, more in particular free of acidified silica nanoparticles.

11. A method according to any of the preceding claims, wherein the coating composition comprising acid-sintered silica nanoparticles is free of organic silanes, in particular free of organofunctional silanes.

12. A coating assembly comprising a substrate and a silica nanoparticle coating comprising acid-sintered silica nanoparticles thereon, wherein said coating assembly further comprises a

primer coating comprising an organofunctional silane in-between said substrate and said silica nanoparticle coating comprising acid-sintered nanoparticles, with the exception that the organofunctional silane is different from beta-aminoethyl-gamma-aminopropyltrimethoxysilane, wherein the organofunctional silane is chosen from epoxy silanes, amino silanes, acryloyloxy silanes, (meth)acryloyloxy silanes, alkoxy silanes, and any combination or mixture thereof.

13. A coating assembly according to claim 12, wherein the silica nanoparticle coating is obtainable by the method according to any of claims 2 to 5.

14. A coating assembly according to any of claim 12 or 13, wherein the substrate comprises a material selected from the group consisting of polymeric materials, glass, ceramic, organic and inorganic composite material, metal, and any combinations thereof.

15. A coating assembly according to any of claims 12 to 14, wherein the substrate comprises an organic polymeric material, preferably selected from the group consisting of poly(meth)acrylates, polyurethanes, polyesters, polycarbonates, polyolefins, and any combinations or mixtures thereof; more preferably the substrate comprises polymethylmethacrylate.

16. A coating assembly according to any of claims 12 to 15, wherein the organofunctional silane ~~is selected from the group consisting of epoxy silanes, amino silanes, (meth)acryloyloxy silanes, alkoxy silanes, and any combinations or mixtures thereof~~ has the following chemical formula:

$$(R^1O)_m\text{-Si-}[(CH_2)_n\text{-}Y]_{4-m},$$

wherein

R^1 is a $(C_1\text{-}C_6)$alkyl,

m is 1 to 3,

n is 0 to 12,

Y is chosen from alkoxy, epoxycyclohexyl, glycidyl, glycidyloxy, acryloyloxy, (meth)acryloyloxy, $\text{-NH-CH}_2\text{CH}_2\text{-NR}^2\text{R}^3$, $\text{-NR}^2\text{R}^3$, and

R^2 and R^3 are each independently chosen from H, alkyl, phenyl, benzyl, cyclopentyl, and cyclohexyl.

17. A coating assembly according to any of claims 12 to 16, wherein the organofunctional silane is selected from the group consisting of 2-(3,4-epoxycyclohexyl) ethyltrimethoxysilane; (3-glycidoxypropyl) trimethoxysilane; 3-aminopropyltrimethoxysilane;3-(2-aminoethylamino)

propyltrimethoxysilane; tetraethoxysilane; 3-(acryloyloxy) propyl trimethoxysilane; 3-(methacryloyloxy) propyl trimethoxysilane; and any combinations or mixtures thereof.

18. A coating assembly according to any of claims 12 to 17, which has a static water contact angle of less than 50°, preferably less than 30°, more preferably less than 20°, even more preferably less than 10°, most preferably less than 5°, when measured according to the static water contact angle measurement method described in the experimental section.

19. A coating assembly according to any of claims 12 to 18, which has a static water contact angle of less than 30°, preferably less than 20°, more preferably less than 15°, even more preferably less than 10°, after 500 dry abrasion cycles when measured according to the dry abrasion test method described in the experimental section.

20. A coating assembly according to any of claims 12 to 19, which has a static water contact angle of less than 30°, preferably less than 20°, more preferably less than 15°, even more preferably less than 10°, after 500 wet abrasion cycles when measured according to the wet abrasion test method described in the experimental section.

21. A coated article comprising a support and a coating assembly according to any of claims 12 to 20 thereon.

22. Use of a primer coating comprising an organofunctional silane for imparting abrasion resistance and/or UV-stability and/or durability to a silica nanoparticle coating comprising acid-sintered silica nanoparticles coated onto a substrate, with the exception that the organofunctional silane is different from beta-aminoethyl-gamma-aminopropyltrimethoxysilane, wherein the organofunctional silane is chosen from epoxy silanes, amino silanes, acryloyloxy silanes, (meth)acryloyloxy silanes, alkoxy silanes, and any combination or mixture thereof.