In one aspect, the present disclosure provides an aqueous coating composition that includes: a zwitterionic silane; greater than 0 wt-% and up to 50 wt-% of a silicate; a non-zwitterionic anionic silane; and water; wherein the weight percent silicate is based on the total weight of silicate(s) plus silane(s) solids in the composition, whether the composition is a ready-to-use composition or a concentrated composition.

In one embodiment, the present disclosure provides a method of protecting a metallic surface, the method including: providing a coating composition, optionally, diluting the coating composition, if concentrated, to a ready-to-use composition; applying the ready-to-use composition to a metallic surface; and allowing the ready-to-use composition to dry on the metallic surface. The coating composition includes: greater than 0 wt-% and up to 50 wt-% of a silicate; a non-zwitterionic anionic silane; and water; wherein the weight percent silicate is based on the total weight of silicate(s) plus silane(s) solids in the composition, whether the composition is a ready-to-use composition or a concentrated composition.

In another aspect, the present disclosure provides a method of protecting a metallic surface, the method comprising: providing a coating composition comprising: greater than 0 wt-% and up to 50 wt-% of a silicate; a non-zwitterionic anionic silane; and water; wherein the weight percent of silicate is based on the total weight of silicate(s) plus silane(s) solids in the composition, whether the composition is a ready-to-use composition or a concentrated composition; optionally, diluting the coating composition, if concentrated, to a ready-to-use composition; applying the ready-to-use composition to a metallic surface; and allowing the ready-to-use composition to dry on the metallic surface.

In one embodiment, the present disclosure provides a method of cleaning and protecting a metallic surface having contaminants thereon, the method including: providing a coating composition; optionally, diluting the coating composition, if concentrated, to a ready-to-use composition; applying the ready-to-use composition to a metallic surface under conditions effective to remove contaminants from the metallic surface (e.g., such conditions include wiping, scrubbing, etc.); and allowing the ready-to-use composition to dry on the metallic surface. The coating composition includes: greater than 0 wt-% and up to 50 wt-% of a silicate; a non-zwitterionic anionic silane; a surfactant; and water; wherein the weight percent silicate is based on the total weight of

silicate(s) plus silane(s) solids in the composition, whether the composition is a ready-to-use composition or a concentrated composition.

The present disclosure also provides articles that include a metallic surface.

In one embodiment, an article includes a metallic surface having a coating composition of the present disclosure disposed thereon.

In one embodiment, an article includes a metallic surface having a coating disposed thereon, wherein the coating is applied by a method of the present disclosure.

In one embodiment, the present disclosure provides an article having a metallic surface that includes a hardened coating, wherein the hardened coating is hydrophilic and

includes: a silicate; and a non-zwitterionic anionic silane; wherein the hardened coating is attached to the surface associatively.

In another aspect, the present disclosure provides an article comprising a metallic surface having a hardened coating disposed thereon; wherein the hardened coating is hydrophilic and comprises: a silicate; and a non-zwitterionic anionic silane; wherein the hardened coating is attached to the surface associatively.

Definitions

A coating composition of the present disclosure may be in a "ready-to-use" form or a "concentrated" form. Herein, a "ready-to-use" composition is one that is not diluted before coating or cleaning a surface. In contrast, a "concentrated" composition is one that is diluted before coating or cleaning a surface. Dilutions typically seen are 1:1 to 1:500, wherein 1 part of concentrate is added to 1 part water (or 500 parts water).

In the context of a composition, "solids" or "total solids" refers to the amount of solids, without a liquid carrier, unless specified otherwise.

In the context of a coating, a "hardened" coating refers to one that is dried upon removal of the water and optional organic solvents. The components of the coating form a network of silane(s) plus silicate(s) that are bonded together chemically and/or physically, including ionic bonding, hydrogen bonding, and/or covalent bonding.

Herein, a "metallic surface" refers to a surface that includes elemental metals or alloys of metals. The term also includes surface oxides of such elemental metal or alloy. This term does not include bulk oxides, such as alumina, silica, etc.

In the context of a surface, a "hydrophilic" surface is one that is wet by aqueous solutions, and does not express whether or not the layer absorbs aqueous solutions. Surfaces on which drops of water or aqueous solutions exhibit an advancing water contact angle of less than 45° are referred to as "hydrophilic" per ASTM D7334-08. Hydrophobic surfaces have a water contact angle of 90° or greater.

The terms "comprises" and variations thereof do not have a limiting meaning where these terms appear in the description and claims. Such terms will be understood to imply the inclusion of a stated step or element or group of steps or elements but not the exclusion of any other step or element or group of steps or elements. By "consisting of" is meant including, and limited to, whatever follows the phrase "consisting of." Thus, the

phrase "consisting of" indicates that the listed elements are required or mandatory, and that no other elements may be present. By "consisting essentially of" is meant including any elements listed after the phrase, and limited to other elements that do not interfere with or contribute to the activity or action specified in the disclosure for the listed

p+q=3.

4. The composition of claim 1 wherein the silicate is an inorganic silicate selected from lithium silicate, sodium silicate, potassium silicate, or a combination thereof.

5. The composition of claim 1 wherein the non-zwitterionic anionic silane comprises one or more associative functional groups out of the following set: a non-zwitterionic sulfonate-functional silane, a non-zwitterionic carboxylate-functional silane, a non-zwitterionic phosphate-functional silane, a non-zwitterionic phosphonic acid-functional silane, a non-zwitterionic phosphonate-functional silane, or a combination thereof.

6. The composition of claim 5 wherein the non-zwitterionic anionic silane has the following formula (Formula I):

$$[(MO)(Q^2)_nSi(XCH_2V^{t-})_{3-n}]Y_{2/nr}^{+r}$$

(I)

wherein:

each Q^2 is independently selected from hydroxyl, alkyl groups containing from 1 to 4 carbon atoms, and alkoxy groups containing from 1 to 4 carbon atoms;

M is selected from hydrogen, alkali metals, and organic cations of strong organic bases having an average molecular weight of less than 150 and a pKa of greater than 11;

X is an organic linking group;

V^{t-} is $-SO_3^-$, $-CO_2^-$, $-OPO_3^{2-}$, $-PO_3^{2-}$, $-OP(=O)(R)O^-$, or a combination thereof, wherein t is 1 or 2, and R is an aliphatic, aromatic, branched, linear, cyclic, or heterocyclic group, or a combination thereof;

Y is selected from hydrogen, alkaline earth metals, organic cations of protonated weak bases having an average molecular weight of less than 200 and a

pKa of less than 11, alkali metals, and organic cations of strong organic bases having an average molecular weight of less than 150 and a pKa of greater than 11, provided that M is hydrogen when Y is selected from hydrogen, alkaline earth metals and organic cations of said protonated weak bases;

r is equal to the valence of Y; and

n is 1 or 2.

7. A method of protecting a metallic surface, the method comprising:

providing a coating composition comprising:

greater than 0 wt-% and up to 50 wt-% of a silicate;

a non-zwitterionic anionic silane; and

water;

wherein the weight percent of silicate is based on the total weight of silicate(s) plus silane(s) solids in the composition, whether the composition is a ready-to-use composition or a concentrated composition;

optionally, diluting the coating composition, if concentrated, to a ready-to-use composition;

applying the ready-to-use composition to a metallic surface; and

allowing the ready-to-use composition to dry on the metallic surface.

8. The method of claim 7 wherein the coating composition further comprises a zwitterionic silane, and where the zwitterionic silane comprises a zwitterionic sulfonate-functional silane, a zwitterionic carboxylate-functional silane, a zwitterionic

phosphate-functional silane, a zwitterionic phosphonic acid-functional silane, a zwitterionic phosphonate-functional silane, or a combination thereof.

9. The method of claim 8 wherein the zwitterionic silane has the following formula (Formula II):

$$(R^1O)_p\text{-}Si(Q^1)_q\text{-}W\text{-}N^+(R^2)(R^3)\text{-}(CH_2)_m\text{-}Z^{t-}$$

(II)

wherein:

each R^1 is independently a hydrogen, methyl group, or ethyl group;

each Q^1 is independently selected from hydroxyl, alkyl groups containing from 1 to 4 carbon atoms, and alkoxy groups containing from 1 to 4 carbon atoms;

each R^2 and R^3 is independently a saturated or unsaturated, straight chain, branched, or cyclic organic group, which may be joined together, optionally with atoms of the group W, to form a ring;

W is an organic linking group;

Z^{t-} is $-SO_3^-$, $-CO_2^-$, $-OPO_3^{2-}$, $-PO_3^{2-}$, $-OP(=O)(R)O^-$, or a combination thereof, wherein t is 1 or 2, and R is an aliphatic, aromatic, branched, linear, cyclic, or heterocyclic group, or a combination thereof;

p and m are integers of 1 to 10;

q is 0 or 1; and

p+q=3.

10. The method of claim 9 wherein the silicate is an inorganic silicate selected from lithium silicate, sodium silicate, potassium silicate, or a combination thereof.

11. The method of claim 7 wherein the non-zwitterionic anionic silane comprises one or more associative functional groups.

12. The method of claim 11 wherein the non-zwitterionic anionic silane comprise a non-zwitterionic sulfonate-functional silane, a non-zwitterionic carboxylate-functional

silane, a non-zwitterionic phosphate-functional silane, a non-zwitterionic phosphonic acid-functional silane, a non-zwitterionic phosphonate-functional silane, or a combination thereof.

13. The method of claim 12 wherein the non-zwitterionic anionic silane has the following formula (Formula I):

$$[(MO)(Q^2)_nSi(XCH_2V^{t-})_{3-n}]Y_{2/nr}^{+r}$$

(I)

wherein:

each Q^2 is independently selected from hydroxyl, alkyl groups containing from 1 to 4 carbon atoms, and alkoxy groups containing from 1 to 4 carbon atoms;

M is selected from hydrogen, alkali metals, and organic cations of strong organic bases having an average molecular weight of less than 150 and a pKa of greater than 11;

X is an organic linking group;

V^{t-} is $-SO_3^-$, $-CO_2^-$, $-OPO_3^{2-}$, $-PO_3^{2-}$, $-OP(=O)(R)O^-$, or a combination thereof, wherein t is 1 or 2, and R is an aliphatic, aromatic, branched, linear, cyclic, or heterocyclic group, or a combination thereof;

Y is selected from hydrogen, alkaline earth metals, organic cations of protonated weak bases having an average molecular weight of less than 200 and a pKa of less than 11, alkali metals, and organic cations of strong organic bases having an average molecular weight of less than 150 and a pKa of greater than 11, provided that M is hydrogen when Y is selected from hydrogen, alkaline earth metals and organic cations of said protonated weak bases;

r is equal to the valence of Y; and

n is 1 or 2.

14. The method of claim 7 wherein the metallic surface comprises stainless steel, aluminum, anodized aluminum, titanium, zinc, silver, a surface oxide thereof, or a combination thereof.

15. The method of claim 7 further comprising applying the ready-to-use composition to the metallic surface under conditions effective to remove contaminants from the metallic surface; and allowing the ready-to-use composition to dry on the metallic surface.

16. An article comprising a metallic surface having a hardened coating disposed thereon; wherein the hardened coating is hydrophilic and comprises:

a silicate; and

a non-zwitterionic anionic silane;

wherein the hardened coating is attached to the surface associatively.

17. The article of claim 16 wherein the metal surface comprises stainless steel, aluminum, anodized aluminum, titanium, zinc, silver, a surface oxide thereof, or a combination thereof.

18. The article of claim 16 wherein the hardened coating is less than 100 nm thick.

19. The article of claim 16 wherein the metallic surface forms at least a portion of a refrigerator, dishwasher, stove, oven, microwave, exhaust hood, fryer, grease trap, food-preparation table, cabinet, toilet stall partition, urinal partition, decorative or functional wall cladding in or on an elevator or escalator, wall in a commercial building, decorative or functional panel in an automobile, metal case for an electronic article, piece of manufacturing equipment, or tool.