consumer goods, where their contact with humans and the environment is inevitable, there is now a strong push in the industry to switch to more human- and environmentally-friendly alternatives.

[004] While a handful of alternative tribological coatings exist, they fail to offer the same performance as their fluorinated counterparts. Solutions based on organosilanes and organophosphorus compounds typically have low shelf-life stability, are easily degraded or worn off during use, and provide inferior lubricity to the coated substrate. Additionally, conventional lubricants such as those based on a layer of liquid oil or dry powders can be easily removed from a substrate or can be transferred to users in the case of high-touch applications. Therefore, existence of a surface-bound material that can reduce friction or stiction and does not contain fluorine is an unmet need.

[005] The disclosed composition, method of using it to form a surface having reduced friction or stiction, and article comprising the surface overcome one or more of the problems set forth above and/or other problems of the prior art.

SUMMARY

[005a] In an aspect, there is a provided a composition for decreasing at least one of friction or stiction of a surface, the composition comprising:

a first part comprising:

(a) at least one organosilane;

(b) at least one organophosphorus; or

(c) a combination of at least one organosilane and at least one organophosphorus, and

a second part comprising at least one polymer,

wherein (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the attached layer,

wherein the first part and the second part of the composition are found in an amount sufficient to decrease friction, stiction or both, of the surface relative to the surface in untreated form.

[006] Consistent with some disclosed examples, compositions for decreasing at least one of friction or stiction of a surface are disclosed. In some examples, the composition comprises: a first part comprising: (a) at least one organosilane; (b) at least one organophosphorus; or (c) a combination of at least one organosilane and at least one organophosphorus. The composition disclosed herein also comprises a second part comprising at least one polymer. In some examples, (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the attached layer, wherein the first part and the second part of the composition are found in an

amount sufficient to decrease friction, stiction or both, of the surface relative to the surface in untreated form.

[006a] In another aspect, there is provided a method of decreasing at least one of friction or stiction of a surface, the method comprising:

applying to the surface of a material, a composition comprising:

a first part comprising:

(a) at least one organosilane;

(b) at least one organophosphorus;

(c) a combination of at least one organosilane and at least one organophosphorus, and

a second part comprising at least one polymer,

wherein (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the said attached layer,

wherein the first part and the second part of the composition are found in an amount sufficient to decrease friction, stiction or both, of the surface relative to the surface in untreated form.

[007] Consistent with some examples, there is disclosed a method of decreasing at least one of friction or stiction of a surface, the method comprising applying to the surface of a material, a composition as described herein. For example, the method uses a composition comprising: a first part comprising: (a) at least one organosilane; (b) at least one organophosphorus; or (c) a combination of at least one organosilane and at least one organophosphorus. The composition disclosed herein also comprises a second part comprising at least one polymer. In

some examples, (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the attached layer, wherein the first part and the second part of the composition are found in an amount sufficient to decrease friction, stiction or both, of the surface relative to the surface in untreated form.

[007a] In another aspect, there is provided an article comprising:

at least one surface having a surface treatment thereon, said surface treatment having a composition comprising:

a first part comprising:

(a) at least one organosilane;

(b) at least one organophosphorus or

(c) a combination of at least one organosilane and at least one organophosphorus, and

a second part comprising at least one polymer,

wherein (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the said attached layer,

wherein the composition is found in an amount sufficient to decrease friction or stiction of the surface relative to the surface in untreated form.

[008] Consistent with some examples, there is disclosed an article having at least one surface having a surface treatment thereon, the surface treatment causing the at least one surface to exhibit reduced friction or stiction. The surface treatment comprises a composition as described herein. For example, the composition comprises: a first part comprising: (a) at least one organosilane; (b) at

least one organophosphorus; or (c) a combination of at least one organosilane and at least one organophosphorus. The composition disclosed herein also comprises a second part comprising at least one polymer. In some examples, (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the attached layer, wherein the first part and the

We Claim:

1. A composition for decreasing at least one of friction or stiction of a surface, the composition comprising:

a first part comprising:

(a) at least one organosilane;

(b) at least one organophosphorus; or

(c) a combination of at least one organosilane and at least one organophosphorus, and

a second part comprising at least one polymer,

wherein (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the attached layer,

wherein the first part and the second part of the composition are found in an amount sufficient to decrease friction, stiction or both, of the surface relative to the surface in untreated form.

2. The composition of claim 1, wherein the at least one organosilane comprises a molecule with at least one leaving group.

3. The composition of claim 2, wherein the at least one leaving group comprises an alkoxy or a chloride group.

4. The composition of claim 1, wherein the at least one organosilane has at least one group that is not a leaving group.

5. The composition of claim 4, wherein the at least one group that is not a leaving group comprises an alkyl, aromatic, silane, silicone, unsaturated (vinyl), epoxy, thiol, or cyclic group.

6. The composition of claim 5, wherein the alkyl group has between 1 to 100 carbons.

7. The composition of claim 6, wherein the organosilane includes an alkyl group and comprises dodecyl triethoxysilane, octadecyl trimethoxysilane, octadecyltriethoxysilane, hexadecyltrichlorosilane, or derivatives of those compounds.

8. The composition of claim 5, wherein the organosilane includes an aromatic group and comprises 1-napthyltrimethoxysilane, p-tolyltrimethoxysilane, phenyltriethoxysilane, benzyltriethoxysilane, or derivatives of those compounds.

9. The composition of claim 5, wherein the organosilane includes an unsaturated (vinyl) group and comprises vinyltrimethoxysilane, allyltrimethoxysilane, or derivatives of those compounds.

10. The composition of claim 5, wherein the organosilane includes a thiol group and comprises 3-(trimethoxysilyl)propanethiol, 11-mercaptoundecyltrimethoxysilane, bis[3-(triethoxysilyl)propyl]disulfide, bis[3-(triethoxysilyl)propyl]tetrasulfide, or derivatives of those compounds.

11. The composition of claim 5, wherein the organosilane includes an epoxy group and comprises 2-(3,4-epoxycyclohexyl)ethyltrimethoxysilane, (3-glycidoxypropyl)trimethoxysilane, or derivatives of those compounds.

12. The composition of claim 5, wherein the organosilane includes a cyclic group and comprises cyclohexyltrichlorosilane, cyclopentyltrimethoxysilane, cyclopentyltrichlorosilane, or derivatives of those compounds.

13. The composition of claim 5, wherein the organosilane includes an additional silane group and comprises 1,2-bis(triethoxysilyl)ethane, 1,8-

bis(triethoxysilyl)octane, bis(trimethoxysilylethyl)benzene, 1,2-bis(trimethoxysilyl)decane, 1,6-bis(trimethoxysilyl)hexane, tris(triethoxysilylpropyl)amine or derivatives of those compounds.

14. The composition of claim 1, wherein the organophosphorus comprises a molecule that has at least one group comprising an alkyl, aromatic, silicone, unsaturated (vinyl), epoxy, thiol, phosphonic acid, or cyclic group.

15. The composition of claim 14, wherein the alkyl group has between 1 to 100 carbons.

16. The composition of claim 1, wherein the organophosphorus comprises methyl phosphonic acid, (2,4-xylyl)phosphonic acid, octadecylphosphonic acid, (aminomethyl)phosphonic acid, 6-phosphonohexanoic acid, hexadecylphosphonic acid, n-Dodecylphosphonic acid, (12-phosphonododecyl)phosphonic acid, 1,4-phenylenebis(phosphonic acid), N,N′-2-methylpiperazinebis(methylene phosphonic acid), or combinations thereof.

17. The composition of claim 1, wherein the second part comprises a polymer with a molecular weight of 1 kDa to 10000 kDa.

18. The composition of claim 1, wherein the at least one polymer comprises a silicone, polyolefin, polystyrene, rubber, wax, polyether, copolymers thereof, or combinations thereof.

19. The composition of claim 18, where the silicone comprises polydimethylsiloxane, polyphenylsiloxane, copolymers thereof, or combinations thereof.

20. The composition of claim 18, where the polyolefin comprises polyethylene, polypropylene, polybutene, polyisobutylene, polyisoprene, copolymers thereof, or combinations thereof.

21. The composition of claim 18, where the wax comprises waxes based on ethylene bis(stearamide), carnauba wax, lanolin, is part of a wax emulsion, or combinations thereof.

22. The composition of claim 1, wherein the polymer includes hydroxyl, silanol, amine, aldehyde, or thiol functional groups, or combinations thereof.

23. The composition of claim 1, wherein the at least one polymer has a kinematic viscosity of 1 to 10000 cSt when taken on its own.

24. The composition of claim 1, further comprising at least one solvent in an appropriate amount for dissolving the first part, the second part, or both.

25. The composition of claim 24, wherein the at least one solvent is selected from a polar solvent, a nonpolar solvent, or mixtures thereof.

26. The composition of claim 25, wherein the non-polar solvent is selected from methylcyclohexane, isoparaffinic solvents, mineral spirits, or mixtures thereof.

27. The composition of claim 25, wherein the polar solvent is selected from water, ethanol, methanol, ammonia, hydrofluoric acid, acetic acid, or mixtures thereof.

28. The composition of claim 25, wherein the at least one solvent comprises both ethanol and methylcyclohexane.

29. The composition of claim 25, wherein the at least one solvent comprises a mixture of at least one polar and at least one nonpolar solvent

comprising a volume ratio of nonpolar solvent(s) to polar solvent(s) of between 10 to 1 and 1 to 10.

30. The composition of claim 25, wherein the at least one solvent comprises 2 to 99.1 weight percent of the composition.

31. The composition of claim 1, wherein the total amount of the first and the second part combined constitutes 0.1 to 98 weight percent of the composition.

32. The composition of claim 1, wherein the weight ratio of the first part to the second part ranges between 10 to 1 and 1 to 10.

33. The composition of claim 1, wherein the organophosphorus comprises 0.01 to 90 weight percent of the first part.

34. The composition of claim 1, where there is at least one organosilane comprising only leaving groups and at least one organosilane comprising at least one non-leaving group, wherein the weight ratio of silanes with only leaving groups to silanes with at least one non-leaving group ranges between 1 to 100 and 10 to 1.

35. The composition of claim 1, which further imparts enhanced hydrophobicity to said surface, as evidenced by an increase in water contact angle on said surface compared to an untreated surface.

36. The composition of claim 1, which imparts enhanced anti-corrosion properties to said surface when said surface is exposed to salt water, sebum, sweat, damp heat or combinations thereof, compared to an untreated surface.

37. The composition of claim 1, which further comprises one or more additives.

38. The composition of claim 37, wherein the one or more additives are selected from triazole derivatives, hindered phenols, metal halides, and thioethers, or combinations thereof.

39. The composition of claim 1, further comprising a material having a two-dimensional morphology.

40. The composition of claim 39, wherein the material having a two-dimensional morphology comprises hexagonal boron nitride (hBN), molybdenum disulfide (MoS), graphene or combinations thereof.

41. A method of decreasing at least one of friction or stiction of a surface, the method comprising:

applying to the surface of a material, a composition comprising:

a first part comprising:

(a) at least one organosilane;

(b) at least one organophosphorus;

(c) a combination of at least one organosilane and at least one organophosphorus, and

a second part comprising at least one polymer,

wherein (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the said attached layer,

wherein the first part and the second part of the composition are found in an amount sufficient to decrease friction, stiction or both, of the surface relative to the surface in untreated form.

42. An article comprising:

at least one surface having a surface treatment thereon, said surface treatment having a composition comprising:

a first part comprising:

(a) at least one organosilane;

(b) at least one organophosphorus or

(c) a combination of at least one organosilane and at least one organophosphorus, and

a second part comprising at least one polymer,

wherein (a), (b) or (c) of the first part is configured as an attached layer on the surface, and the at least one polymer of the second part is adjacent to the said attached layer,

wherein the composition is found in an amount sufficient to decrease friction or stiction of the surface relative to the surface in untreated form.