

Quaternary Azeotrope and Azeotrope-Like Compositions For Solvent and Cleaning Applications

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims the benefit of U.S. Provisional Application Serial No.
5 62/788,481, filed January 4, 2019, the disclosure of which is incorporated herein by
reference in its entirety.

TECHNICAL FIELD

This invention relates to quaternary azeotrope or azeotrope-like compositions
comprising trans-dichloroethylene and three or more additional components. The
10 compositions described herein may be useful, for example, in cleaning and defluxing
fluid applications.

BACKGROUND

Chlorofluorocarbon (CFC) and hydrofluorocarbon (HFC) compounds have
15 been used extensively in the area of semiconductor manufacturing to clean surfaces
such as magnetic disk media. However, chlorine-containing compounds such as CFC
compounds are detrimental to the Earth's ozone layer. In addition, many of the
hydrofluorocarbons used to replace CFC compounds have been found to contribute to
global warming. Therefore, there is a need to identify new environmentally safe
20 solvents for cleaning applications, such as removing residual flux, lubricant or oil
contaminants, and particles. There is also a need for identification of new solvents for
deposition of fluorolubricants and for drying or dewatering of substrates that have
been processed in aqueous solutions.

DESCRIPTION OF DRAWINGS

25 Figure 1 shows the ternary composition space for the compositions comprising
trans-1,2-dichloroethylene (t-DCE), methyl perfluoroheptene ether (MPHE),
1,1,2,2,3,3,4-heptafluorocyclopentane (HFCP), and 3 weight percent ethanol at the
boiling point of Composition 1 (45°C; indicated by the star).

SUMMARY

The present application provides, *inter alia*, a composition comprising:

- i) trans-1,2-dichloroethylene;
- ii) a second component selected from a hydrofluoroolefin, a
5 hydrofluoroether, and a hydrochlorofluoroolefin;
- iii) a third component which is a hydrofluorocarbon; and
- iv) a fourth component selected from a C₁₋₆ alcohol, a C₃₋₆ ketone, a C₅₋₈
alkane, a C₃₋₆ cycloalkane, and a C₁₋₆ alkyl acetate.

The present application further provides processes for dissolving a solute,
10 comprising contacting and mixing said solute with a sufficient quantity of a
composition described herein.

The present application further provides a processes of cleaning a surface,
comprising contacting a composition described herein with said surface.

The present application further provides a process for removing at least a
15 portion of water from the surface of a wetted substrate, comprising contacting the
substrate with the composition described herein, and then removing the substrate from
contact with the composition.

The present application further provides processes of depositing a
fluorolubricant on a surface, comprising:

- 20 a) combining a fluorolubricant and a solvent to form a lubricant-solvent
combination, wherein the solvent comprises a composition provided herein;
- b) contacting the lubricant-solvent combination with the surface; and
- c) evaporating the solvent from the surface to form a fluorolubricant
coating on the surface.

25 Unless otherwise defined, all technical and scientific terms used herein have
the same meaning as commonly understood by one of ordinary skill in the art to
which this invention belongs. Methods and materials are described herein for use in
the present invention; other, suitable methods and materials known in the art can also
be used. The materials, methods, and examples are illustrative only and not intended
30 to be limiting. All publications, patent applications, patents, sequences, database
entries, and other references mentioned herein are incorporated by reference in their

entirety. In case of conflict, the present specification, including definitions, will control

DETAILED DESCRIPTION

5 Nonflammable fluorinated solvent based cleaning agents are useful in industrial vapor degreasing and flux removal applications. Hydrofluorocarbons (HFCs) and such blends have been successful in critical cleaning due to the combination of good safety and health attributes, zero ozone depletion, good solvency, and low viscosity properties. Recent environmental concerns and
10 regulations have shifted from ozone depletion to global warming in view of global treaties (*e.g.*, F-gas regulations in the European Union, SNAP rulings in the United States, and the like). Thus, there is a use for alternative cleaning agents which are environmentally sustainable and exhibit low GWP. In addition, azeotrope and azeotrope-like compositions are desirable for critical cleaning applications, as such
15 composition do not fractionate after distillation, condensation, and re-mixing. Azeotrope and azeotrope-like compositions therefore provide consistent cleaning performance, minimize solvent maintenance time, and improve production throughput. High solvency is also desirable for degreasing and the ability to remove flux residues from lead free and no clean solders on electronic components.

20 Accordingly, the present application provides new quaternary azeotropic and azeotrope-like compositions comprising mixtures of trans-dichloroethylene and three or more additional components. These compositions have utility in many of the applications formerly served by HFCs. The compositions of the present application possess some or all of the desired properties discussed above, little or no
25 environmental impact, and the ability to dissolve oils, greases, and/or fluxes. Thus, the compositions provided herein may be useful as cleaning agents, defluxing agents, and/or degreasing agents.

Definitions and Abbreviations

30 As used herein, the terms “comprises,” “comprising,” “includes,” “including,” “has,” “having” or any other variation thereof, are intended to cover a non-exclusive inclusion. For example, a process, method, article, or apparatus that comprises a list

of elements is not necessarily limited to only those elements but may include other elements not expressly listed or inherent to such process, method, article, or apparatus. Further, unless expressly stated to the contrary, “or” refers to an inclusive or and not to an exclusive or. For example, a condition A or B is satisfied by any one
5 of the following: A is true (or present) and B is false (or not present), A is false (or not present) and B is true (or present), and both A and B are true (or present).

As used herein, the term “consisting essentially of” is used to define a composition, method that includes materials, steps, features, components, or elements, in addition to those literally disclosed provided that these additional included
10 materials, steps, features, components, or elements do not materially affect the basic and novel characteristic(s) of the claimed invention, especially the mode of action to achieve the desired result of any of the processes of the present invention. The term “consists essentially of” or “consisting essentially of” occupies a middle ground between “comprising” and “consisting of”.

Also, use of “a” or “an” are employed to describe elements and components described herein. This is done merely for convenience and to give a general sense of the scope of the invention. This description should be read to include one or at least one and the singular also includes the plural unless it is obvious that it is meant otherwise.

As used herein, the term “about” is meant to account for variations due to experimental error (*e.g.*, plus or minus approximately 10% of the indicated value). All measurements reported herein are understood to be modified by the term “about”, whether or not the term is explicitly used, unless explicitly stated otherwise.

Throughout the definitions, the term “C_{n-m}” indicates a range which includes
25 the endpoints, wherein n and m are integers and indicate the number of carbons. Examples include C₁₋₆, C₅₋₈, and the like.

As used herein, the term “C_{n-m} alkyl”, refers to a saturated hydrocarbon group that may be straight-chain or branched, having n to m carbons. Exemplary alkyl moieties include, but are not limited to, methyl, ethyl, *n*-propyl, isopropyl, *n*-butyl,
30 *tert*-butyl, isobutyl, *sec*-butyl, *n*-pentyl, 3-pentyl, *n*-hexyl, *n*-heptyl, *n*-octyl, and the like. In some embodiments, the alkyl group contains from 1 to 8 carbon atoms, from 5

to 8 carbon atoms, from 1 to 6 carbon atoms, from 1 to 3 carbon atoms, or from 1 to 2 carbon atoms.

As used herein, the term “C_{n-m} alcohol” refers to a group of formula (C_{n-m} alkyl)-OH, wherein the alkyl group has n to m carbon atoms. Exemplary alcohols include, but are not limited to methanol, ethanol, propanol, isopropanol, and butanol. In some embodiments, the alcohol is a C₁₋₆ alcohol.

As used herein, the term “C_{n-m} ketone” refers to a group of formula (C_{n-m} alkyl)C(O)(C_{n-m} alkyl), wherein each alkyl independently has n to m carbon atoms. Exemplary ketones include, but are not limited to dimethyl ketone (*i.e.*, acetone), ethyl methyl ketone, diethyl ketone, and the like. In some embodiments, the ketone is a C₃₋₆ ketone.

As used herein, the term “C_{n-m} alkane”, refers to a saturated hydrocarbon compound that may be straight-chain or branched, having n to m carbons. Exemplary alkanes include, but are not limited to methane, ethane, n-propane, isopropane, n-butane, tert-butane, isobutane, sec-butane, n-pentane, 3-pentane, n-hexane, n-heptane, n-octane, and the like. In some embodiments, the alkane is a C₅₋₈ alkane.

As used herein, the term “C_{n-m} cycloalkane” refers to non-aromatic cyclic hydrocarbon compound having n to m carbon atoms. Exemplary cycloalkanes include, but are not limited to cyclopropane, cyclobutane, cyclopentane, cyclohexane, cycloheptane, cyclooctane, and the like. In some embodiments, the cycloalkane is a C₃₋₆ cycloalkane.

As used herein, the term “C_{n-m} alkyl acetate” refers to a compound of formula (C_{n-m} alkyl)OC(O)CH₃, wherein the alkyl has n to m carbon atoms. Exemplary alkyl acetates include, but are not limited to methyl acetate (*i.e.*, CH₃OC(O)CH₃), ethyl acetate (*i.e.*, CH₃CH₂OC(O)CH₃), propyl acetate (*i.e.*, CH₃CH₂CH₂OC(O)CH₃), isopropyl acetate (*i.e.*, (CH₃)₂CHOC(O)CH₃), and the like. In some embodiments, the alkyl acetate is a C₁₋₆ alkyl acetate. In some embodiments, the alkyl acetate is a C₁₋₃ alkyl acetate.

When an amount, concentration, or other value or parameter is given as either a range, preferred range or a list of upper preferable values and/or lower preferable values, this is to be understood as specifically disclosing all ranges formed from any pair of any upper range limit or preferred value and any lower range limit or preferred

value, regardless of whether ranges are separately disclosed. Where a range of numerical values is recited herein, unless otherwise stated, the range is intended to include the endpoints thereof, and all integers and fractions within the range.

As recognized in the art, an azeotropic composition is an admixture of two or more different components which, when in liquid form and (1a) under a given constant pressure, will boil at a substantially constant temperature, which temperature may be higher or lower than the boiling temperatures of the individual components, or (1b) at a given constant temperature, will boil at a substantially constant pressure, which pressure may be higher or lower than the boiling pressure of the individual components, and (2) will boil at substantially constant composition, which phase compositions, while constant, are not necessarily equal (see, *e.g.*, M. F. Doherty and M.F. Malone, *Conceptual Design of Distillation Systems*, McGraw-Hill (New York), 2001, 185).

A homogeneous azeotrope, in which a single vapor phase is in equilibrium with a single liquid phase, has, in addition to properties (1a), (1b), and (2) above, the composition of each component is the same in each of the coexisting equilibrium phases. The general term “azeotrope” is a commonly used alternative name for a homogeneous azeotrope.

As used herein, an “azeotrope-like” composition refers to a composition that behaves like an azeotropic composition (*i.e.*, has constant boiling characteristics or a tendency not to fractionate upon boiling or evaporation). Hence, during boiling or evaporation, the vapor and liquid compositions, if they change at all, change only to a minimal or negligible extent. In contrast, the vapor and liquid compositions of non-azeotrope-like compositions change to a substantial degree during boiling or evaporation.

As used herein, the terms “azeotrope-like” or “azeotrope-like behavior” refer to compositions that exhibit dew point pressure and bubble point pressure with virtually no pressure differential. In some embodiments, the difference in the dew point pressure and bubble point pressure at a given temperature is 3% or less. In some embodiments, the difference in the bubble point and dew point pressures is 5% or less.

Chemical Abbreviations

The following abbreviations may be used throughout the present application.

CFC: chlorofluorocarbon

t-DCE: *trans*-1,2-dichloroethylene

5 **EtOH**: ethanol

HCFO: hydrochlorofluoroolefin

HCFO-1233zd(Z): (Z)-1-chloro-3,3,3-trifluoropropene

HCFO-1233zd(E): (E)-1-chloro-3,3,3-trifluoropropene

HCFO-1233yd(Z): (Z)-1-chloro-2,3,3-trifluoro-1-propene

10 **HFC**: hydrofluorocarbon

HFC-43-10mee or XF: 1,1,1,2,2,3,4,5,5,5-decafluoropentane

HFCP: 1,1,2,2,3,3,4-heptafluorocyclopentane

HFE: hydrofluoroether

HFE-7000: perfluoroisopropylmethyl ether

15 **HFE-7100**: mixture of 1-methoxyperfluorobutane and 1-methoxyperfluoroisobutane

HFE-7200: mixture of 1-ethoxyperfluorobutane and 1-ethoxyperfluoroisobutane

HFE-7300: 3-methoxyperfluoroisohexane

20 **HFE-347pc-f**: 1,1,2,2-tetrafluoroethyl-2,2,2-trifluoroethyl ether

HFO: hydrofluoroolefin

HFO-1336mzz(Z): (Z)-1,1,1,4,4,4, hexafluoro-2-butene

MeOH: methanol

MPHE: methyl perfluoroheptene ether

25 **Novec™ 7300**: 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane

Azeotrope and Azeotrope-Like Compositions

The present application provides compositions, comprising:

- 30 i) *trans*-1,2-dichloroethylene;
- ii) a second component selected from a hydrofluoroolefin, a hydrofluoroether, a hydrochlorofluoroolefin, and an alkyl perfluoroalkene ether;

- iii) a third component which is a hydrofluorocarbon; and
- iv) a fourth component selected from a C₁₋₆ alcohol, a C₃₋₆ ketone, a C₅₋₈ alkane, a C₃₋₆ cycloalkane, and a C₁₋₆ alkyl acetate.

In some embodiments, the composition is an azeotrope (*i.e.*, azeotropic) composition. In some embodiments, the second, third, and forth components are present in the composition in amounts effective to form an azeotrope composition with the trans-1,2-dichloroethylene.

In some embodiments, the composition is an azeotrope-like composition. In some embodiments, the second, third, and forth components are present in the composition in amounts effective to form an azeotrope-like composition with the trans-1,2-dichloroethylene.

In some embodiments, the composition comprises about 75 to about 85 weight percent trans-1,2-dichloroethylene, for example, about 75 to about 83, about 75 to about 81, about 75 to about 79, about 75 to about 77, about 77 to about 85, about 77 to about 83, about 77 to about 81, about 77 to about 79, about 79 to about 85, about 79 to about 83, about 79 to about 81, about 81 to about 85, about 81 to about 83, or about 83 to about 85 weight percent trans-1,2-dichloroethylene. In some embodiments, the composition comprises about 79 to about 81 weight percent trans-1,2-dichloroethylene. In some embodiments, the composition comprises about 80 weight percent trans-1,2-dichloroethylene.

In some embodiments, the composition comprises about 70 to about 80 weight percent trans-1,2-dichloroethylene, for example, about 70 to about 78, about 70 to about 76, about 70 to about 74, about 70 to about 72, about 72 to about 80, about 72 to about 78, about 72 to about 76, about 72 to about 74, about 74 to about 80, about 74 to about 78, about 74 to about 76, about 76 to about 80, about 76 to about 78, or about 78 to about 80 weight percent trans-1,2-dichloroethylene. In some embodiments, the composition comprises about 74 to about 76 weight percent trans-1,2-dichloroethylene. In some embodiments, the composition comprises about 75 weight percent trans-1,2-dichloroethylene.

In some embodiments, the second component is a hydrofluoroolefin. In some embodiments, the hydrofluoroolefin is (Z)-1,1,1,4,4,4-hexafluoro-2-butene.

In some embodiments, the second component is a hydrofluoroether. In some embodiments, the hydrofluoroether is selected from HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, and 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane. In some embodiments, the hydrofluoroether is selected from
5 HFE-7000, HFE-7100, HFE-7200, HFE-7300, and HFE-347pc-f. In some embodiments, the hydrofluoroether is 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.

In some embodiments, the composition comprises about 5 to about 15 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane, for
10 example, about 5 to about 10 or about 10 to about 15 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane. In some embodiments, the composition comprises about 10 to about 12 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane. In some
15 embodiments, the composition comprises about 11 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.

In some embodiments, the second component is a hydrochlorofluoroolefin. In some embodiments, the hydrochlorofluoroolefin is selected from HCFO-1233zd(Z), HCFO-1233zd(E), and HCFO-1233yd(Z).

In some embodiments, the second component is an alkyl perfluoroalkene
20 ether. In some embodiments, the alkyl perfluoroalkene ether is methyl perfluoroheptene ether.

In some embodiments, the composition comprises about 1 to about 5 weight percent methyl perfluoroheptene ether, for example, about 1 to about 4, about 1 to about 3, about 1 to about 2, about 2 to about 5, about 2 to about 4, about 2 to about 3,
25 about 3 to about 5, about 3 to about 4, or about 4 to about 5 weight percent methyl perfluoroheptene ether. In some embodiments, the composition comprises about 3 to about 5 weight percent methyl perfluoroheptene ether. In some embodiments, the composition comprises about 4 weight percent methyl perfluoroheptene ether.

In some embodiments, the methyl perfluoroheptene ether comprises a mixture
30 two or more structural and/or stereoisomers.

In some embodiments, the methyl perfluoroheptene ether comprises a mixture of about 48 to about 52 weight percent 5-methoxy perfluoro-3-heptene, about 18 to

about 22 weight percent 3-methoxy perfluoro-3-heptene, about 18 to about 22 weight percent 4-methoxy perfluoro-2-heptene, and about 6 to about 10 weight percent 4-methoxy perfluoro-3-heptene.

In some embodiments, the methyl perfluoroheptene ether comprises a mixture
5 of about 50 weight percent 5-methoxy perfluoro-3-heptene, about 20 weight percent 3-methoxy perfluoro-3-heptene, about 20 weight percent 4-methoxy perfluoro-2-heptene, and about 8 weight percent 4-methoxy perfluoro-3-heptene.

In some embodiments, the methyl perfluoroheptene ether comprises a mixture
of about 48 to about 52 weight percent 5-methoxy (E)-perfluoro-3-heptene, about 12
10 to about 16 weight percent 3-methoxy (E)-perfluoro-3-heptene, about 4 to about 8 weight percent 3-methoxy (Z)-perfluoro-3-heptene, about 18 to about 22 weight percent 4-methoxy (E)-perfluoro-2-heptene, about 1 to about 3 weight percent 4-methoxy (Z)-perfluoro-3-heptene, and about 4 to about 8 weight percent 4-methoxy (E)-perfluoro-3-heptene.

In some embodiments, the methyl perfluoroheptene ether comprises a mixture
of about 50 weight percent 5-methoxy (E)-perfluoro-3-heptene, about 14 weight
percent 3-methoxy (E)-perfluoro-3-heptene, about 6 weight percent 3-methoxy (Z)-
perfluoro-3-heptene, about 20 weight percent 4-methoxy (E)-perfluoro-2-heptene,
about 2 weight percent 4-methoxy (Z)-perfluoro-3-heptene, and about 6 weight
20 percent 4-methoxy (E)-perfluoro-3-heptene.

In some embodiments, the third component is selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane. In some embodiments, the third component is 1,1,2,2,3,3,4-heptafluorocyclopentane.

In some embodiments, the composition comprises about 1 to about 15 weight
25 percent 1,1,2,2,3,3,4-heptafluorocyclopentane, for example, about 1 to about 10, about 1 to about 5, or about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane.

In some embodiments, the composition comprises about 10 to about 15 weight
30 percent 1,1,2,2,3,3,4-heptafluorocyclopentane, for example, about 10 to about 14, about 10 to about 13, about 10 to about 12, about 10 to about 11, about 11 to about 15, about 11 to about 14, about 11 to about 13, about 11 to about 12, about 12 to

about 15, about 12 to about 14, about 12 to about 13, about 13 to about 15, about 13 to about 14, or about 14 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane. In some embodiments, the composition comprises about 11 to about 13 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane. In some
5 embodiments, the composition comprises about 12 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane.

 In some embodiments, the composition comprises about 5 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane, for example, about 5 to about 10 or about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane. In some
10 embodiments, the composition comprises about 9 to about 11 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane. In some embodiments, the composition comprises about 10 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane.

 In some embodiments, the fourth component is a C₁₋₆ alcohol. In some embodiments, the C₁₋₆ alcohol is selected from methanol, ethanol, and isopropanol.

15 In some embodiments, the C₁₋₆ alcohol is ethanol. In some embodiments, the composition comprises about 1 to about 5 weight percent ethanol, for example, about 1 to about 4, about 1 to about 3, about 1 to about 2, about 2 to about 5, about 2 to about 4, about 2 to about 3, about 3 to about 5, about 3 to about 4, or about 4 to about 5 weight percent ethanol. In some embodiments, the composition comprises about 2
20 to about 4 weight percent ethanol. In some embodiments, the composition comprises about 3 weight percent ethanol.

 In some embodiments, the C₁₋₆ alcohol is isopropanol. In some embodiments, the composition comprises about 1 to about 5 weight percent isopropanol, for example, about 1 to about 4, about 1 to about 3, about 1 to about 2, about 2 to about 5,
25 about 2 to about 4, about 2 to about 3, about 3 to about 5, about 3 to about 4, or about 4 to about 5 weight percent isopropanol. In some embodiments, the composition comprises about 2 to about 4 weight percent isopropanol. In some embodiments, the composition comprises about 3 weight percent isopropanol.

 In some embodiments, the fourth component is a C₃₋₆ ketone. In some
30 embodiments, the C₃₋₆ ketone is acetone.

 In some embodiments, the fourth component is a C₅₋₈ alkane. In some embodiments, the C₅₋₈ alkane is n-hexane. In some embodiments, the composition

comprises about 1 to about 5 weight percent n-hexane, for example, about 1 to about 4, about 1 to about 3, about 1 to about 2, about 2 to about 5, about 2 to about 4, about 2 to about 3, about 3 to about 5, about 3 to about 4, or about 4 to about 5 weight percent n-hexane. In some embodiments, the composition comprises about 2 to about 4 weight percent n-hexane. In some embodiments, the composition comprises about 4 weight percent n-hexane.

In some embodiments, the fourth component is a C₃₋₆ cycloalkane. In some embodiments, the C₃₋₆ cycloalkane is cyclopentane.

In some embodiments, the fourth component is a C₁₋₆ alkyl acetate. In some embodiments, the C₁₋₆ alkyl acetate is ethyl acetate.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), methyl perfluoroheptene ether, and 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
- iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and
- iv) a fourth component selected from methanol, ethanol, isopropanol, and n-hexane.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), and methyl perfluoroheptene ether;
- iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and
- iv) a fourth component selected from methanol, ethanol, and isopropanol.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;

ii) a second component which is methyl perfluoroheptene ether or 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;

iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and

iv) a fourth component selected from methanol, ethanol, isopropanol, and n-hexane.

In some embodiments, the composition comprises:

i) trans-1,2-dichloroethylene;

ii) a second component which is methyl perfluoroheptene ether;

iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and

iv) a fourth component selected from methanol, ethanol, and isopropanol.

In some embodiments, the composition comprises:

i) trans-1,2-dichloroethylene;

ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), methyl perfluoroheptene ether, and 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;

iii) a third component which is 1,1,2,2,3,3,4-heptafluorocyclopentane; and

iv) a fourth component selected from methanol, ethanol, isopropanol, and n-hexane.

In some embodiments, the composition comprises:

i) trans-1,2-dichloroethylene;

ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), and methyl perfluoroheptene ether;

iii) a third component which is 1,1,2,2,3,3,4-heptafluorocyclopentane; and

iv) a fourth component selected from methanol, ethanol, and isopropanol.

In some embodiments, the composition comprises:

i) trans-1,2-dichloroethylene;

ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), methyl perfluoroheptene ether, and 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;

5 iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and

iv) a fourth component which is selected from ethanol, isopropanol, and n-hexane.

10 In some embodiments, the composition comprises:

i) trans-1,2-dichloroethylene;

ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), and methyl perfluoroheptene ether;

15 iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and

iv) a fourth component which is ethanol.

In some embodiments, the composition comprises:

20 i) trans-1,2-dichloroethylene;

ii) a second component which is methyl perfluoroheptene ether or 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;

iii) a third component selected which is 1,1,2,2,3,3,4-heptafluorocyclopentane; and

25 iv) a fourth component selected from methanol, ethanol, isopropanol, and n-hexane.

In some embodiments, the composition comprises:

i) trans-1,2-dichloroethylene;

ii) a second component which is methyl perfluoroheptene ether;

30 iii) a third component selected which is 1,1,2,2,3,3,4-heptafluorocyclopentane; and

iv) a fourth component selected from methanol, ethanol, and isopropanol.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) a second component which is methyl perfluoroheptene ether or 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
- 5 iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and
- iv) a fourth component which is selected from ethanol, isopropanol, and n-hexane.

10 In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) a second component which is methyl perfluoroheptene ether;
- iii) a third component selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane; and
- 15 iv) a fourth component which is ethanol.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), methyl perfluoroheptene ether, and 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
- 20 iii) a third component which is 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) a fourth component which is selected from ethanol, isopropanol, and n-hexane.
- 25 hexane.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) a second component selected from (Z)-1,1,1,4,4,4-hexafluoro-2-butene, HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, HCFO-1233zd(Z), HCFO-1233zd(E), HCFO-1233yd(Z), and methyl perfluoroheptene ether;
- 30 iii) a third component which is 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) a fourth component which is ethanol.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) methyl perfluoroheptene ether;
- iii) 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- 5 iv) ethanol.

In some embodiments, the composition comprising trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol has a boiling point of about 44°C to about 46°C at a pressure of about 101 kPa.

In some embodiments, the composition comprising trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol has
10 a boiling point of about 45°C at a pressure of about 101 kPa.

In some embodiments, the composition provided herein consists essentially of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol.

15 In some embodiments, the composition provided herein consists of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol.

In some embodiments, the composition comprises:

- i) about 75 to about 85 weight percent trans-1,2-dichloroethylene;
- 20 ii) about 1 to about 5 weight percent methyl perfluoroheptene ether;
- iii) about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 1 to about 5 weight percent ethanol.

In some embodiments, the composition comprises:

- 25 i) about 79 to about 81 weight percent trans-1,2-dichloroethylene;
- ii) about 3 to about 5 weight percent methyl perfluoroheptene ether;
- iii) about 11 to about 13 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 2 to about 4 weight percent ethanol.

30 In some embodiments, the composition comprises:

- i) about 81 weight percent trans-1,2-dichloroethylene;
- ii) about 4 weight percent methyl perfluoroheptene ether;

- iii) about 12 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 3 weight percent ethanol.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- 5 ii) methyl perfluoroheptene ether;
- iii) 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) isopropanol.

In some embodiments, the composition comprising trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane; and
10 isopropanol has a boiling point of about 45°C to about 47°C at a pressure of about 101 kPa.

In some embodiments, the composition comprising trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane; and isopropanol has a boiling point of about 46°C at a pressure of about 101 kPa.

15 In some embodiments, the composition consists essentially of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and isopropanol.

In some embodiments, the composition consists of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and
20 isopropanol.

In some embodiments, the composition comprises:

- i) about 75 to about 85 weight percent trans-1,2-dichloroethylene;
- ii) about 1 to about 5 weight percent methyl perfluoroheptene ether;
- iii) about 10 to about 15 weight percent 1,1,2,2,3,3,4-
25 heptafluorocyclopentane; and
- iv) about 1 to about 5 weight percent isopropanol.

In some embodiments, the composition comprises:

- i) about 79 to about 81 weight percent trans-1,2-dichloroethylene;
- ii) about 3 to about 5 weight percent methyl perfluoroheptene ether;
- 30 iii) about 11 to about 13 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 2 to about 4 weight percent isopropanol.

In some embodiments, the composition comprises:

- i) about 81 weight percent trans-1,2-dichloroethylene;
- ii) about 4 weight percent methyl perfluoroheptene ether;
- iii) about 12 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 3 weight percent isopropanol.

In some embodiments, the composition comprises:

- i) trans-1,2-dichloroethylene;
- ii) 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
- iii) 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) n-hexane.

In some embodiments, the composition comprising trans-1,2-dichloroethylene, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane, 1,1,2,2,3,3,4-heptafluorocyclopentane, and n-hexane has a boiling point of about 45°C to about 47°C at a pressure of about 101 kPa.

In some embodiments, the composition comprising trans-1,2-dichloroethylene, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane, 1,1,2,2,3,3,4-heptafluorocyclopentane, and n-hexane has a boiling point of about 46°C at a pressure of about 101 kPa.

In some embodiments, the composition consists essentially of trans-1,2-dichloroethylene, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane, 1,1,2,2,3,3,4-heptafluorocyclopentane, and n-hexane.

In some embodiments, the composition consists of trans-1,2-dichloroethylene, 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane, 1,1,2,2,3,3,4-heptafluorocyclopentane, and n-hexane.

In some embodiments, the composition comprises:

- i) about 70 to about 80 weight percent trans-1,2-dichloroethylene;
- ii) about 5 to about 15 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
- iii) about 5 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 1 to about 5 weight percent n-hexane.

In some embodiments, the composition comprises:

- i) about 74 to about 76 weight percent trans-1,2-dichloroethylene;
 - ii) about 10 to about 12 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
 - iii) about 8 to about 10 weight percent 1,1,2,2,3,3,4-
5 heptafluorocyclopentane; and
 - iv) about 2 to about 4 weight percent n-hexane.
- In some embodiments, the composition comprises:
- i) about 75 weight percent trans-1,2-dichloroethylene;
 - ii) about 11 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-
10 (trifluoromethyl)pentane;
 - iii) about 10 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
 - iv) about 4 weight percent n-hexane.

Methods of Use

15 In some embodiments, the compositions described herein may useful as cleaning agents, defluxing agents, and/or degreasing agents. Accordingly, the present application provides a process of cleaning a surface, comprising contacting a composition provided herein with said surface. In some embodiments, the process comprises removing a residue from a surface or substrate, comprising contacting the
20 surface or substrate with a composition provided herein and recovering the surface or substrate from the composition.

In some embodiments, the present application further provides a process for dissolving a solute, comprising contacting and mixing said solute with a sufficient quantity of a composition provided herein.

25 In some embodiments, the surface or substrate may be an integrated circuit device, in which case, the residue comprises rosin flux or oil. The integrated circuit device may be a circuit board with various types of components, such as Flip chips, μ BGAs, or Chip scale packaging components. The surface or substrate may additionally be a metal surface such as stainless steel. The rosin flux may be any type
30 commonly used in the soldering of integrated circuit devices, including but not limited to RMA (rosin mildly activated), RA (rosin activated), WS (water soluble),

and OA (organic acid). Oil residues include but are not limited to mineral oils, motor oils, and silicone oils.

In some embodiments, the present application provides a process for removing at least a portion of water from the surface of a wetted substrate, or surface, or device, comprising contacting the substrate, surface, or device with a composition provided
5 herein, and then removing the substrate, surface, or device from contact with the composition.

In some embodiments, the compositions provided herein further comprises one or more additive components (*i.e.*, the compositions comprise *trans*-1,2-
10 dichloroethylene, a second component as described herein, a third component as described herein, a fourth component as described herein, and one or more additive components as described herein). Exemplary additives include, but are not limited to, surfactants and fluorolubricants.

In some embodiments, the compositions provided herein further comprises at least one surfactant suitable for dewatering or drying the substrate. Exemplary
15 surfactants include, but are not limited to, alkyl dimethyl ammonium isooctyl phosphates, tert-alkyl amines (*e.g.*, tert-butyl amine), perfluoro alkyl phosphates, dimethyl decenamide, fluorinated alkyl polyether, quaternary amines (*e.g.*, ammonium salts), and glycerol monostearate.

The means for contacting a device, surface, or substrate is not critical and may
20 be accomplished, for example, by immersion of the device, surface, or substrate, in a bath containing the composition provided herein, spraying the device, surface, or substrate with the composition provided herein, or wiping the device, surface, or substrate with a material (*e.g.*, a cloth) that has been wet with the composition.

Alternatively, a composition provided herein may also be used in a vapor degreasing
25 or defluxing apparatus designed for such residue removal. Such vapor degreasing or defluxing equipment is available from various suppliers such as Forward Technology (a subsidiary of the Crest Group, Trenton, NJ), Trek Industries (Azusa, CA), and Ultronix, Inc. (Hatfield, PA) among others.

The most advanced, highest recording densities and lowest cost method of
30 storing digital information involves writing and reading magnetic flux patterns from rotating disks coated with magnetic materials. A magnetic layer, where information is

stored in the form of bits, is sputtered onto a metallic support structure. Next an overcoat, usually a carbon-based material, is placed on top of the magnetic layer for protection and finally a lubricant is applied to the overcoat. A read-write head flies above the lubricant and the information is exchanged between the head and the magnetic layer. In a relentless attempt to increase the efficiency of information transfer, hard drive manufacturers have reduced the distance between the head and the magnetic layer, or fly-height, to less than 100 Angstroms.

Invariably, during normal disk drive application, the head and the disk surface will make contact. To reduce wear on the disk, from both sliding and flying contacts, it must be lubricated.

Fluorolubricants are widely used as lubricants in the magnetic disk drive industry to decrease the friction between the head and disk, that is, reduce the wear and therefore minimize the possibility of disk failure.

There is a need in the industry for improved methods for deposition of fluorolubricants. The use of certain solvents, such as CFC-113 and PFC-5060, has been regulated due to their impact on the environment. Therefore, solvents that will be used in this application should consider environmental impact. Also, such solvent must dissolve the fluorolubricant and form a substantially uniform or uniform coating of fluorolubricant. Additionally, existing solvents have been found to require higher fluorolubricant concentrations to produce a given thickness coating and produce irregularities in uniformity of the fluorolubricant coating.

In some embodiments, the fluorolubricants of the present disclosure comprise perfluoropolyether (PFPE) compounds, or lubricant comprising X-1P®, which is a phosphazene-containing disk lubricant. These perfluoropolyether compounds are sometimes referred to as perfluoroalkylethers (PFAE) or perfluoropolyalkylethers (PFPAE). These PFPE compounds range from simple perfluorinated ether polymers to functionalized perfluorinated ether polymers. PFPE compounds of different varieties that may be useful as fluorolubricant in the present invention are available from several sources. In some embodiments, fluorolubricants useful in the processes provided herein include, but are not limited to, Krytox® GLP 100, GLP 105 or GLP 160 (The Chemours Co., LLC, Fluoroproducts, Wilmington, DE, 19898, USA); Fomblin® Z-Dol 2000, 2500 or 4000, Z-Tetraol, or Fomblin® AM 2001 or AM 3001

(sold by Solvay Solexis S.p.A., Milan, Italy); Demnum™ LR-200 or S-65 (offered by Daikin America, Inc., Osaka, Japan); X-1P® (a partially fluorinated hixaphenoxy cyclotriphosphazene disk lubricant available from Quixtor Technologies Corporation, a subsidiary of Dow Chemical Co, Midland, MI); and mixtures thereof. The Krytox®
5 lubricants are perfluoroalkylpolyethers having the general structure $F(CF(CF_3)CF_2O)_n-CF_2CF_3$, wherein n ranges from 10 to 60. The Fomblin® lubricants are functionalized perfluoropolyethers that range in molecular weight from 500 to 4000 atomic mass units and have general formula $X-CF_2-O(CF_2-CF_2-O)_p-(CF_2O)_q-CF_2-X$, wherein X may be $-CH_2OH$, p+q is 40 to 180, and p/q is 0.5 to 2; $CH_2(O-CH_2-CH_2)_nOH$, wherein n is 10 to 60, $CH_2OCH_2CH(OH)CH_2OH$, or $-CH_2O-CH_2-$
10 piperonyl. The Demnum™ oils are perfluoropolyether-based oils ranging in molecular weight from 2700 to 8400 atomic mass units. Additionally, new lubricants are being developed such as those from Moresco (Thailand) Co., Ltd, which may be useful in processes provided herein.

15 The fluorolubricants described herein may additionally comprise additives to improve the properties of the fluorolubricant. X-1P®, which may serve as the lubricant itself, is often added to other lower cost fluorolubricants in order to increase the durability of disk drives by passivating Lewis acid sites on the disk surface responsible for PFPE degradation. Other common lubricant additives may be used in
20 the fluorolubricants useful in the processes provided herein.

The fluorolubricants described herein may further comprise Z-DPA (Hitachi Global Storage Technologies, San Jose, CA), a PFPE terminated with dialkylamine end-groups. The nucleophilic end-groups serve the same purpose as X1P®, thus providing the same stability without any additive.

25 The surface on which the fluorolubricant may be deposited is any solid surface that may benefit from lubrication. Semiconductor materials such as silica disks, metal or metal oxide surfaces, vapor deposited carbon surfaces or glass surfaces are representative of the types of surfaces that may be used in the processes described herein. In some embodiments, the processes provided herein are particularly useful in
30 coating magnetic media such as computer drive hard disks. In the manufacture of computer disks, the surface may be a glass, or aluminum substrate with layers of magnetic media that is also coated by vapor deposition with a thin (10-50 Angstrom)

layer of amorphous hydrogenated or nitrogenated carbon. The fluorolubricant may be deposited on the surface disk indirectly by applying the fluorolubricant to the carbon layer of the disk.

The first step of combining the fluorolubricant and composition provided
5 herein (*i.e.*, as a solvent) may be accomplished in any suitable manner such as mixing in a suitable container such as a beaker or other container that may be used as a bath for the deposition process. The fluorolubricant concentration in the composition provided herein may be from about 0.010 percent (wt/wt) to about 0.50 percent (wt/wt).

10 The step of contacting said combination of fluorolubricant and composition provided herein with the surface may be accomplished in any manner appropriate for said surface (considering the size and shape of the surface). A hard drive disk must be supported in some manner such as with a mandrel or some other support that may fit through the hole in the center of the disk. The disk will thus be held vertically such
15 that the plane of the disk is perpendicular to the solvent bath. The mandrel may have different shapes including but not limited to, a cylindrical bar, or a V-shaped bar. The mandrel shape will determine the area of contact with the disk. The mandrel may be constructed of any material strong enough to hold the disk, including but not limited to metal, metal alloy, plastic, or glass. Additionally, a disk may be supported
20 vertically upright in a woven basket or be clamped into a vertical position with one or more clamps on the outer edge. The support may be constructed of any material with the strength to hold the disk, such as metal, metal alloy, plastic or glass. However the disk is supported, the disk will be lowered into a container holding a bath of the fluorolubricant/solvent (*i.e.*, the composition provided herein) combination. The bath
25 may be held at room temperature or be heated or cooled to temperatures ranging from about 0 °C to about 50 °C.

Alternatively, the disk may be supported as described above and the bath may be raised to immerse the disk. In either case, the disk may then be removed from the bath (either by lowering the bath or by raising the disk). Excess
30 fluorolubricant/solvent combination can be drained into the bath.

Either of the processes for contacting the fluorolubricant/solvent combination with the disk surface of either lowering the disk into a bath or raising a bath to

immerse the disk are commonly referred to as dip coating. Other processes for contacting the disk with the fluorolubricant/solvent combination may be used in processes described hererin, including, but not limited to, spraying or spin coating.

When the disk is removed from the bath, the disk will have a coating of
5 fluorolubricant and some residual solvent (*i.e.*, the composition provided herein) on its surface. The residual solvent may be evaporated. Evaporation is usually performed at room temperature. However, other temperatures both above and below room temperature may be used as well for the evaporation step. Temperatures ranging from about 0 °C to about 100 °C may be used for evaporation.

10 The surface, or the disk if the surface is a disk, after completion of the coating process, will be left with a substantially uniform or uniform coating of fluorolubricant that is substantially free of solvent. The fluorolubricant may be applied to a thickness of less than about 300 nm, and alternately to a thickness of about 100 to about 300 nm.

15 A uniform fluorolubricant coating is desired for proper functioning of a disk and so areas of varying fluorolubricant thickness are undesirable on the surface of the disk. As more and more information is being stored on the same size disk, the read/write head must get closer and closer to the disk in order to function properly. If irregularities due to variation in coating thickness are present on the surface of the
20 disk, the probability of contact of the head with these areas on the disk is much greater. While there is a desire to have enough fluorolubricant on the disk to flow into areas where it may be removed by head contact or other means, coating that is too thick may cause “smear,” a problem associated with the read/write head picking up excess fluorolubricant.

25 One specific coating thickness irregularity observed in the industry is that known as the “rabbit ears” effect. These irregularities are visually detected on the surface of the disk after deposition of the fluorolubricant using the existing solvent systems. When the disk is contacted with the solution of fluorolubricant in solvent and then removed from the solution, any points where the solution may accumulate and
30 not drain readily develop drops of solution that do not readily drain off. One such point of drop formation is the contact point (or points) with the mandrel or other support device with the disk. When a V-shaped mandrel is used, there are two contact

points at which the mandrel contacts the inside edge of the disk. When solution of fluorolubricant forms drops in these locations that do not drain off when removed from the bath, an area of greater thickness of fluorolubricant is created when the solvent evaporates. The two points of contact with the disk produces what is known
5 as a “rabbit ears” effect, because the areas of greater fluorolubricant thickness produce a pattern resembling rabbit ears visually detectable on the disk surface.

When dip coating is used for depositing fluorolubricant on the surface, the pulling-up speed (speed at which the disk is removed from the bath), and the density of the fluorolubricant and the surface tension are relevant for determining the
10 resulting film thickness of the fluorolubricant. Awareness of these parameters for obtaining the desired film thickness is required. Details on how these parameters effect coatings are given in, “Dip-Coating of Ultra-Thin Liquid Lubricant and its Control for Thin-Film Magnetic Hard Disks” in IEEE Transactions on Magnetism, vol. 31, no. 6, November 1995, the disclosure of which is incorporated herein by reference
15 in its entirety.

EXAMPLES

The invention will be described in greater detail by way of specific examples. The following examples are offered for illustrative purposes, and are not intended to
20 limit the invention in any manner. Those of skill in the art will readily recognize a variety of non-critical parameters which can be changed or modified to yield essentially the same results.

Example 1. Single Plate Distillation Analysis of Composition 1

25 A mixture of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol was prepared and distilled in a single-plate distillation column at a pressure of 760 mm Hg per standard ASTM method D 1078. Boiling flask temperatures were monitored directly to 1°C. The distillation was stopped at 50% distilled by weight, and both distillate and heel
30 samples were taken for determination of composition by gas chromatography. Table 1 shows the components of Composition 1, which was an azeotropic composition and exhibited a boiling point of 45°C at 101 kPa.

Table 1.

Component	Initial Composition (wt %)	Heel Composition (wt %)	Distillate Composition (wt %)
EtOH	3	2.3	3.97
t-DCE	80.93	80.5	82.28
HFCP	12.09	12.7	11.59
MPHE	3.98	4.5	2.16
Boiling point (°C)	45.1	45.3	

Without being bound by theory, it is believed that Composition 1 may be useful as a cleaning agent which is effective in removing various oils, greases, and fluxes used in electronic and industrial manufacturing processes. For vapor degreasing applications, an azeotropic cleaning blend is particularly beneficial, as the composition does not exhibit substantial composition change upon distillation, condensation, and re-mixing. This provides reliable cleaning results and decreases the risk of flammability. Furthermore, azeotrope compositions reduce the overall operation costs by eliminating the need for constant monitoring of the ratio of solvating and rinse agent, thereby reducing production downtimes and increase throughput. In addition, Composition 1 contains the highest concentration of *trans*-1,2-dichloroethylene in its class. Composition 1 is expected to be non-flammable, to have high kb value (>90), and to be a useful remover for flux and ionic contaminations due to the presence of ethanol in the composition. Composition 1 is expected to have a GWP (100yr ITH) of 30 based on the mass-based weighted average of the pure components' GWP.

Example 2. Stability Analysis of Composition 1

A 200 gram mixture of Composition 1 was charged into a modified Soxhlet extractor to simulate vapor degreaser operations used in precision cleaning. The composition was heated to 45°C for 4 hours. Both rinse sump (distillate) and boil sump (boil flask) were analyzed by GC/FID. The distillation rate was about 200 gram/hour. As shown in Table 2, Composition 1 exhibited minimal changes in the composition during the Soxhlet analysis.

Table 2.

Component	Initial Composition (wt%)	Rinse Sump Composition (wt%)	Boil Sump Composition (wt%)	Boiling Point (°C)
t-DCE	80.93	80.94	80.64	45°C
MPHE	3.98	3.93	4.31	
HFCP	12.09	12.08	12.21	
EtOH	3.00	3.05	2.84	

Example 3. Stability Analysis of Composition 2

A 200 gram mixture of trans-1,2-dichloroethylene (t-DCE), methyl
 5 perfluoroheptene ether (MPHE), 1,1,2,2,3,3,4-heptafluorocyclopentane (HFCP), and
 isopropanol (IPA) was charged into a modified Soxhlet extractor to simulate vapor
 degreaser operations used in precision cleaning. The composition was heated to 45°C
 for 4 hours. Both rinse sump (distillate) and boil sump (boil flask) were analyzed by
 GC/FID. The distillation rate was about 200 gram/hour. As shown in Table 3,
 10 Composition 2 exhibited minimal changes in the composition during the Soxhlet
 analysis.

Table 3.

Component	Initial Composition (wt%)	Rinse Sump Composition (wt%)	Boil Sump Composition (wt%)	Boiling Point (°C)
IPA	3.04	2.67	3.53	46
t-DCE	80.95	82.59	78.75	
HFCP	11.96	11.91	12.08	
MPHE	4.05	2.83	5.64	

Example 4. Cleaning Effectiveness Factor (CEF) Analysis of Composition 1

15 Composition 1 was decanted into a 1000 mL beaker with a condensing coil
 and heated to the boiling point (45.2°C) using a hot plate. Three precleaned 304
 stainless steel coupons were weighed on an analytical balance (initial weight). A thin
 film of Mobil 600W cylinder oil was applied to one surface of each coupon and
 excess was removed with a wipe. Each coupon was then reweighed to determine the
 20 soiled weight and subsequently placed in the vapor phase of the boiling composition
 for ten minutes. The coupons were then removed and allowed to dry and off-gas for
 ten minutes before reweighing (post cleaning weight) to determine the cleaning

effectiveness factor of the solvent blend. Results of the cleaning analysis are shown in Table 4 and the CEF was determined according to Equation 1.

Equation 1.

$$\text{CEF} = (\text{soiled weight} - \text{post cleaning weight}) / (\text{soiled weight} - \text{initial weight})$$

5

Table 4.

Coupon ID	Initial Weight (g)	Soiled Weight (g)	Post-Cleaned Weight (g)	CEF
1A	19.6634	19.6831	19.6634	100.0%
1B	20.0253	20.0606	20.0251	100.6%
1C	20.0811	20.1169	20.0808	100.8%

Example 5. Cleaning Effectiveness Factor (CEF) Analysis of Composition 2

Composition 2 was decanted into a 1000 mL beaker with a condensing coil and heated to the boiling point (46.2°C) using a hot plate. Three pre-cleaned 304 stainless steel coupons were weighed on an analytical balance (initial weight). A thin film of Mobil 600W cylinder oil was applied to one surface of each coupon and excess was removed with a wipe. Each coupon was then reweighed to determine the soiled weight and subsequently placed in the vapor phase of the boiling composition for ten minutes. The coupons were then removed and allowed to dry and off-gas for ten minutes before reweighing (post cleaning weight) to determine the cleaning effectiveness factor of the solvent blend. Results of the cleaning analysis are shown in Table 5 and the CEF was determined according to Equation 1.

15

Table 5.

Coupon	Initial Weight (g)	Soiled Weight (g)	Post-Cleaned Weight (g)	CEF
2A	19.6632	19.6828	19.6633	99.5%
2B	20.0250	20.0706	20.0251	99.8%
2C	20.0807	20.1054	20.0807	100.0%

Example 6. Single Plate Distillation Analysis of Composition 3

Composition 3 was prepared and distilled in a 25-plate distillation column at a pressure of 760 mm Hg per standard ASTM method D 1078. Head and flask temperatures were monitored directly to 1°C. Distillate samples were taken throughout the distillation for determination of composition by gas chromatography.

Table 6 shows the components of Composition 3, which was an azeotrope-like composition and exhibited a boiling point of 46°C at 101 kPa.

Table 6.

Component	Initial (%wt)	Distillate (%wt)	Boiling Point (°C)
HFCP	9.76	10.33	46
Novec 7300	11.42	11.05	
t-DCE	75.15	76.02	
n-hexane	3.67	2.6	

5 Example 7. Quaternary Azeotropic Ranges

The quaternary azeotrope-like composition ranges were determined via percent deviation between the dew point and bubble point pressures, relative to the bubble point pressure. Dew point and bubble point pressures, at the operating boiling temperature of 45°C from Example 2, of compositions with varying composition at a fixed weight percent of 3% ethanol were determined using an equal fugacity-based vapor-liquid equilibria (VLE) calculation, and the percent deviation for each given composition was calculated. Binary VLE data for each of the constituent binaries in the quaternary system were experimentally collected such that activity coefficient model binary interaction parameters could be fit for each binary. Figure 1 demonstrates the bubble to dew point pressure deviation in the slice of ternary composition space, sliced at a weight percent of 3% ethanol. The contour lines follow values of constant percent deviation between the dew point and bubble point pressures. As shown Figure 1, the 3% deviation contour line includes compositions from 0.1% to 32% HFCP; 0.1% to 15% MPHE; and 65% to 96.8% t-DCE; at 3% ethanol.

OTHER EMBODIMENTS

1. In some embodiments, the present application provides an azeotrope or azeotrope-like composition, comprising:
 - 25 i) trans-1,2-dichloroethylene;
 - ii) a second component selected from a hydrofluoroolefin, a hydrofluoroether, a hydrochlorofluoroolefin, and an alkyl perfluoroalkene ether;
 - iii) a third component which is a hydrofluorocarbon; and

- iv) a fourth component selected from a C₁₋₆ alcohol, a C₃₋₆ ketone, a C₅₋₈ alkane, a C₃₋₆ cycloalkane, and a C₁₋₆ alkyl acetate.
2. The composition of embodiment 1, wherein the second component is a hydrofluoroolefin.
- 5 3. The composition of embodiment 1 or 2, wherein the hydrofluoroolefin is (Z)-1,1,1,4,4,4-hexafluoro-2-butene.
4. The composition of embodiment 1, wherein the second component is a hydrofluoroether.
5. The composition of embodiment 1 or 4, wherein the hydrofluoroether is
10 selected from HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, and 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.
6. The composition of embodiment 1 or 4, wherein the hydrofluoroether is 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.
7. The composition of embodiment 5 or 6, wherein the composition comprises
15 about 5 to about 15 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.
8. The composition of embodiment 5 or 6, wherein the composition comprises about 10 to about 12 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.
- 20 9. The composition of embodiment 1, wherein the second component is a hydrochlorofluoroolefin.
10. The composition of embodiment 1 or 9, wherein the hydrochlorofluoroolefin is selected from HCFO-1233zd(Z), HCFO-1233zd(E), and HCFO-1233yd(Z).
11. The composition of embodiment 1, wherein the second component is an alkyl
25 perfluoroalkene ether.
12. The composition of embodiment 1 or 11, wherein the alkyl perfluoroalkene ether is methyl perfluoroheptene ether.
13. The composition of embodiment 12, wherein methyl perfluoroheptene ether comprises a mixture of about 50 weight percent 5-methoxy perfluoro-3-heptene,
30 about 20 weight percent 3-methoxy perfluoro-3-heptene, about 20 weight percent 4-methoxy perfluoro-2-heptene, and about 8 weight percent 4-methoxy perfluoro-3-heptene.

14. The composition of embodiment 12 or 13, wherein the composition comprises about 1 to about 5 weight percent methyl perfluoroheptene ether.
15. The composition of embodiment 12 or 13, wherein the composition comprises about 3 to about 5 weight percent methyl perfluoroheptene ether.
- 5 16. The composition of any one of embodiments 1 to 15, wherein the third component is selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane.
17. The composition of any one of embodiments 1 to 16, wherein the third component is 1,1,2,2,3,3,4-heptafluorocyclopentane.
- 10 18. The composition of embodiment 17, wherein the composition comprises about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane.
19. The composition of embodiment 17, wherein the composition comprises about 11 to about 13 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane.
20. The composition of any one of embodiments 1 to 19, wherein the fourth
15 component is a C₁₋₆ alcohol.
21. The composition of any one of embodiments 1 to 20, wherein the C₁₋₆ alcohol is selected from methanol, ethanol, and isopropanol.
22. The composition of any one of embodiments 1 to 20, wherein the C₁₋₆ alcohol is ethanol.
- 20 23. The composition of embodiment 20, wherein the composition comprises about 1 to about 5 weight percent ethanol.
24. The composition of embodiment 20, wherein the composition comprises about 2 to about 4 weight percent ethanol.
25. The composition of any one of embodiments 1 to 20, wherein the C₁₋₆ alcohol
25 is isopropanol.
26. The composition of embodiment 20, wherein the composition comprises about 1 to about 5 weight percent isopropanol.
27. The composition of embodiment 20, wherein the composition comprises about 2 to about 4 weight percent isopropanol.
- 30 28. The composition of any one of embodiments 1 to 19, wherein the fourth component is a C₃₋₆ ketone.

29. The composition of any one of embodiments 1 to 19 and 28, wherein the C₃₋₆ ketone is acetone.
30. The composition of any one of embodiments 1 to 19, wherein the fourth component is a C₅₋₈ alkane.
- 5 31. The composition of any one of embodiments 1 to 19 and 30, wherein the C₅₋₈ alkane is n-hexane.
32. The composition of any one of embodiments 1 to 19 and 30, wherein the composition comprises about 1 to about 5 weight percent n-hexane.
33. The composition of any one of embodiments 1 to 19 and 30, wherein the
10 composition comprises about 2 to about 4 weight percent n-hexane.
34. The composition of any one of embodiments 1 to 19 and 30, wherein the composition comprises about 4 weight percent n-hexane.
35. The composition of any one of embodiments 1 to 19, wherein the fourth component is a C₃₋₆ cycloalkane.
- 15 36. The composition of any one of embodiments 1 to 19 and 35, wherein the C₃₋₆ cycloalkane is cyclopentane.
37. The composition of any one of embodiments 1 to 19, wherein the fourth component is a C₁₋₆ alkyl acetate.
38. The composition of any one of embodiments 1 to 19 and 37, wherein the C₁₋₆
20 alkyl acetate is ethyl acetate.
39. The composition of any one of embodiments 1 to 38, wherein the composition comprises about 75 to about 85 weight percent trans-1,2-dichloroethylene.
40. The composition of any one of embodiments 1 to 38, wherein the composition comprises about 79 to about 81 weight percent trans-1,2-dichloroethylene.
- 25 41. The composition of embodiment 1, wherein the composition comprises:
i) about 75 to about 85 weight percent trans-1,2-dichloroethylene;
ii) about 1 to about 5 weight percent methyl perfluoroheptene ether;
iii) about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
30 iv) about 1 to about 5 weight percent ethanol.
42. The composition of embodiment 1, wherein the composition comprises:
i) about 79 to about 81 weight percent trans-1,2-dichloroethylene;

- ii) about 3 to about 5 weight percent methyl perfluoroheptene ether;
 - iii) about 11 to about 13 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
 - iv) about 2 to about 4 weight percent ethanol.
- 5 43. The composition of embodiment 1, wherein the composition comprises:
- i) about 81 weight percent trans-1,2-dichloroethylene;
 - ii) about 4 weight percent methyl perfluoroheptene ether;
 - iii) about 12 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
 - iv) about 3 weight percent ethanol.
- 10 44. The composition of any one of embodiments 1, 12 to 15, 17 to 19, 22 to 24, and 39 to 43, wherein the composition has a boiling point of about 44°C to about 46°C at a pressure of about 101 kPa.
45. The composition of any one of embodiments 1, 12 to 15, 17 to 19, 22 to 24, and 39 to 44, wherein the composition consists essentially of trans-1,2-
- 15 dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol.
46. The composition of any one of embodiments 1, 12 to 15, 17 to 19, 22 to 24, and 39 to 45, wherein the composition consists of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol.
- 20 47. The composition of embodiment 1, wherein the composition comprises:
- i) about 75 to about 85 weight percent trans-1,2-dichloroethylene;
 - ii) about 1 to about 5 weight percent methyl perfluoroheptene ether;
 - iii) about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- 25 iv) about 1 to about 5 weight percent isopropanol.
48. The composition of embodiment 1, wherein the composition comprises:
- i) about 79 to about 81 weight percent trans-1,2-dichloroethylene;
 - ii) about 3 to about 5 weight percent methyl perfluoroheptene ether;
 - iii) about 11 to about 13 weight percent 1,1,2,2,3,3,4-
- 30 heptafluorocyclopentane; and
- iv) about 2 to about 4 weight percent isopropanol.
49. The composition of embodiment 1, wherein the composition comprises:

- i) about 81 weight percent trans-1,2-dichloroethylene;
 - ii) about 4 weight percent methyl perfluoroheptene ether;
 - iii) about 12 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
 - iv) about 3 weight percent isopropanol.
- 5 50. The composition of any one of embodiments 1, 12 to 15, 17 to 19, 25 to 27, 39, 40, and 47 to 49, wherein the composition has a boiling point of about 45°C to about 47°C at a pressure of about 101 kPa.
51. The composition of any one of embodiments 1, 12 to 15, 17 to 19, 25 to 27, 39, 40, and 47 to 50, wherein the composition consists essentially of trans-1,2-
- 10 dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and isopropanol.
52. The composition of any one of embodiments 1, 12 to 15, 17 to 19, 25 to 27, 39, 40, and 47 to 51, wherein the composition consists of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and
- 15 isopropanol.
53. The composition of any one of embodiments 1 to 38, wherein the composition comprises about 5 to about 15 weight percent trans-1,2-dichloroethylene.
54. The composition of any one of embodiments 1 to 38, wherein the composition comprises about 10 to about 12 weight percent trans-1,2-dichloroethylene.
- 20 55. The composition of embodiment 1, wherein the composition comprises:
- i) about 70 to about 80 weight percent trans-1,2-dichloroethylene;
 - ii) about 5 to about 15 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
 - iii) about 5 to about 10 weight percent 1,1,2,2,3,3,4-
 - 25 heptafluorocyclopentane; and
 - iv) about 1 to about 5 weight percent n-hexane.
56. The composition of embodiment 1, wherein the composition comprises:
- i) about 74 to about 76 weight percent trans-1,2-dichloroethylene;
 - ii) about 10 to about 12 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-
 - 30 methoxy-4-(trifluoromethyl)pentane;
 - iii) about 8 to about 10 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and

- iv) about 2 to about 4 weight percent n-hexane.
- 57. The composition of embodiment 1, wherein the composition comprises:
 - i) about 75 weight percent trans-1,2-dichloroethylene;
 - ii) about 11 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-
5 (trifluoromethyl)pentane;
 - iii) about 10 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
 - iv) about 4 weight percent n-hexane.
- 58. The composition of any one of embodiments 1, 6 to 8, 17 to 19, 31 to 34, and
53 to 57, wherein the composition has a boiling point of about 45°C to about 47°C at a
10 pressure of about 101 kPa.
- 59. The composition of any one of embodiments 1, 6 to 8, 17 to 19, 31 to 34, and
53 to 58, wherein the composition consists essentially of trans-1,2-dichloroethylene,
1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane, 1,1,2,2,3,3,4-
heptafluorocyclopentane, and n-hexane.
- 15 60. The composition of any one of embodiments 1, 6 to 8, 17 to 19, 31 to 34, and
53 to 59, wherein the composition consists of trans-1,2-dichloroethylene,
1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane, 1,1,2,2,3,3,4-
heptafluorocyclopentane, and n-hexane.
- 61. The composition of any one of embodiments 1 to 60, wherein the composition
20 is an azeotrope composition.
- 62. The composition of any one of embodiments 1 to 60, wherein the composition
is an azeotrope-like composition.
- 63. A process for dissolving a solute, comprising contacting and mixing said
solute with a sufficient quantity of the composition any one of embodiments 1 to 62.
- 25 64. A process of cleaning a surface, comprising contacting the composition of any
one of embodiments 1 to 62 with said surface.
- 65. A process for removing at least a portion of water from the surface of a wetted
substrate, comprising contacting the substrate with the composition of any one of
embodiments 1 to 62, and then removing the substrate from contact with the
30 composition.
- 66. The process of embodiment 65, wherein composition further comprises at
least one surfactant suitable for dewatering or drying the substrate.

67. A process of depositing a fluorolubricant on a surface, comprising:

- a) combining a fluorolubricant and a solvent to form a lubricant-solvent combination, wherein the solvent comprises a composition of any one of embodiments 1 to 62;
- 5 b) contacting the lubricant-solvent combination with the surface; and
- c) evaporating the solvent from the surface to form a fluorolubricant coating on the surface.

It is to be understood that while the invention has been described in conjunction with the detailed description thereof, the foregoing description is intended
10 to illustrate and not limit the scope of the invention, which is defined by the scope of the appended claims. Other aspects, advantages, and modifications are within the scope of the following claims. It should be appreciated by those persons having ordinary skill in the art(s) to which the present invention relates that any of the features described herein in respect of any particular aspect and/or embodiment of the
15 present invention can be combined with one or more of any of the other features of any other aspects and/or embodiments of the present invention described herein, with modifications as appropriate to ensure compatibility of the combinations. Such combinations are considered to be part of the present invention contemplated by this disclosure.

20

WHAT IS CLAIMED IS:

1. An azeotrope or azeotrope-like composition, comprising:
 - i) trans-1,2-dichloroethylene;
 - ii) a second component selected from a hydrofluoroolefin, a hydrofluoroether, a hydrochlorofluoroolefin, and an alkyl perfluoroalkene ether;
 - iii) a third component which is a hydrofluorocarbon; and
 - iv) a fourth component selected from a C₁₋₆ alcohol, a C₃₋₆ ketone, a C₅₋₈ alkane, a C₃₋₆ cycloalkane, and a C₁₋₆ alkyl acetate.
2. The composition of claim 1, wherein the second component is a hydrofluoroolefin.
3. The composition of claim 2, wherein the hydrofluoroolefin is (Z)-1,1,1,4,4,4-hexafluoro-2-butene.
4. The composition of claim 1, wherein the second component is a hydrofluoroether.
5. The composition of claim 4, wherein the hydrofluoroether is selected from HFE-7000, HFE-7100, HFE-7200, HFE-7300, HFE-347pc-f, and 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.
6. The composition of claim 4, wherein the hydrofluoroether is 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane.
7. The composition of claim 1, wherein the second component is a hydrochlorofluoroolefin.
8. The composition of claim 7, wherein the hydrochlorofluoroolefin is selected from HCFO-1233zd(Z), HCFO-1233zd(E), and HCFO-1233yd(Z).

9. The composition of claim 1, wherein the second component is an alkyl perfluoroalkene ether.
10. The composition of claim 9, wherein the alkyl perfluoroalkene ether is methyl perfluoroheptene ether.
11. The composition of claim 10, wherein methyl perfluoroheptene ether comprises a mixture of about 50 weight percent 5-methoxy perfluoro-3-heptene, about 20 weight percent 3-methoxy perfluoro-3-heptene, about 20 weight percent 4-methoxy perfluoro-2-heptene, and about 8 weight percent 4-methoxy perfluoro-3-heptene.
12. The composition of claim 11, wherein the composition comprises about 1 to about 5 weight percent methyl perfluoroheptene ether.
13. The composition of claim 11, wherein the composition comprises about 3 to about 5 weight percent methyl perfluoroheptene ether.
14. The composition of claim 1, wherein the third component is selected from 1,1,2,2,3,3,4-heptafluorocyclopentane, 1,1,1,3,3-pentafluorobutane, and 1,1,1,3,3-pentafluoropropane.
15. The composition of claim 1, wherein the third component is 1,1,2,2,3,3,4-heptafluorocyclopentane.
16. The composition of claim 15, wherein the composition comprises about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane.
17. The composition of claim 15, wherein the composition comprises about 11 to about 13 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane.
18. The composition of claim 1, wherein the fourth component is a C₁₋₆ alcohol.

19. The composition of claim 18, wherein the C₁₋₆ alcohol is selected from methanol, ethanol, and isopropanol.
20. The composition of claim 18, wherein the C₁₋₆ alcohol is ethanol.
21. The composition of claim 20, wherein the composition comprises about 1 to about 5 weight percent ethanol.
22. The composition of claim 20, wherein the composition comprises about 2 to about 4 weight percent ethanol.
23. The composition of claim 1, wherein the fourth component is a C₃₋₆ ketone.
24. The composition of claim 23, wherein the C₃₋₆ ketone is acetone.
25. The composition of claim 1, wherein the fourth component is a C₅₋₈ alkane.
26. The composition of claim 25, wherein the C₅₋₈ alkane is n-hexane.
27. The composition of claim 1, wherein the fourth component is a C₃₋₆ cycloalkane.
28. The composition of claim 27, wherein the C₃₋₆ cycloalkane is cyclopentane.
29. The composition of claim 1, wherein the fourth component is a C₁₋₆ alkyl acetate.
30. The composition of claim 29, wherein the C₁₋₆ alkyl acetate is ethyl acetate.
31. The composition of claim 1, wherein the composition comprises about 75 to about 85 weight percent trans-1,2-dichloroethylene.

32. The composition of claim 1, wherein the composition comprises about 79 to about 81 weight percent trans-1,2-dichloroethylene.

33. The composition of claim 1, wherein the composition comprises:

- i) about 75 to about 85 weight percent trans-1,2-dichloroethylene;
- ii) about 1 to about 5 weight percent methyl perfluoroheptene ether;
- iii) about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 1 to about 5 weight percent ethanol.

34. The composition of claim 1, wherein the composition comprises:

- i) about 79 to about 81 weight percent trans-1,2-dichloroethylene;
- ii) about 3 to about 5 weight percent methyl perfluoroheptene ether;
- iii) about 11 to about 13 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 2 to about 4 weight percent ethanol.

35. The composition of claim 1, wherein the composition comprises:

- i) about 81 weight percent trans-1,2-dichloroethylene;
- ii) about 4 weight percent methyl perfluoroheptene ether;
- iii) about 12 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 3 weight percent ethanol.

36. The composition of claim 35, wherein the composition has a boiling point of about 44°C to about 46°C at a pressure of about 101 kPa.

37. The composition of claim 1, wherein the composition consists essentially of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol.

38. The composition of claim 1, wherein the composition consists of trans-1,2-dichloroethylene, methyl perfluoroheptene ether, 1,1,2,2,3,3,4-heptafluorocyclopentane, and ethanol.

39. The composition of claim 1, wherein the composition is an azeotrope composition.

40. The composition of claim 1, wherein the composition is an azeotrope-like composition.

41. The composition of claim 1, wherein the composition comprises:

- i) about 75 to about 85 weight percent trans-1,2-dichloroethylene;
- ii) about 1 to about 5 weight percent methyl perfluoroheptene ether;
- iii) about 10 to about 15 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 1 to about 5 weight percent isopropanol.

42. The composition of claim 1, wherein the composition comprises:

- i) about 70 to about 80 weight percent trans-1,2-dichloroethylene;
- ii) about 5 to about 15 weight percent 1,1,1,2,2,3,4,5,5,5-decafluoro-3-methoxy-4-(trifluoromethyl)pentane;
- iii) about 5 to about 10 weight percent 1,1,2,2,3,3,4-heptafluorocyclopentane; and
- iv) about 1 to about 5 weight percent n-hexane.

43. A process for dissolving a solute, comprising contacting and mixing said solute with a sufficient quantity of the composition of claim 1.

44. A process of cleaning a surface, comprising contacting the composition of claim 1 with said surface.

45. A process for removing at least a portion of water from the surface of a wetted substrate, comprising contacting the substrate with the composition of claim 1, and then removing the substrate from contact with the composition.

46. The process of claim 45, wherein composition further comprises at least one surfactant suitable for dewatering or drying the substrate.

47. A process of depositing a fluorolubricant on a surface, comprising:

- a) combining a fluorolubricant and a solvent to form a lubricant-solvent combination, wherein the solvent comprises a composition of claim 1;
- b) contacting the lubricant-solvent combination with the surface; and
- c) evaporating the solvent from the surface to form a fluorolubricant coating on the surface.