(12) STANDARD PATENT (11) Application No. **AU 2012200235 B2**
(19) AUSTRALIAN PATENT OFFICE

(54) Title
Compositions comprising a fluoroolefin

(51) International Patent Classification(s)
C09K 5/04 (2006.01) ***C09K 3/30*** (2006.01)
A62D 1/00 (2006.01) ***C10M 171/00*** (2006.01)
C08J 9/14 (2006.01)

(21) Application No: **2012200235** (22) Date of Filing: **2012.01.16**

(43) Publication Date: **2012.02.02**
(43) Publication Journal Date: **2012.02.02**
(44) Accepted Journal Date: **2014.02.20**

(62) Divisional of:
2006218376

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(56) Related Art
WO 2005/108523 A1
WO 2005/108522 A1

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TITLE OF THE INVENTION

COMPOSITIONS COMPRISING A FLUOROOLEFIN

ABSTRACT

The present invention relates to compositions for use in refrigeration, air-conditioning, and heat pump systems wherein the composition comprises a fluoroolefin and at least one other component. The compositions of the present invention are useful in processes for producing cooling or heat, as heat transfer fluids, foam blowing agents, aerosol propellants, and fire suppression and fire extinguishing agents.

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P/00/011
Regulation 3.2

AUSTRALIA

Patents Act 1990

COMPLETE SPECIFICATION

FOR A DIVISIONAL PATENT

ORIGINAL

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Invention Title: COMPOSITIONS COMPRISING A FLUOROOLEFIN

The following statement is a full description of this invention, including the best method of performing it known to the Applicant:-

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TITLE OF INVENTION

COMPOSITIONS COMPRISING A FLUOROOLEFIN

CROSS REFERENCE(S) TO RELATED APPLICATION(S)

The present application is a divisional application from Australian patent application number 2006218376. The entire disclosures of Australian patent application number 2006218376 and its corresponding International application, PCT/US2006/008164, are incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention.

The present invention relates to compositions for use in refrigeration, air-conditioning, and heat pump systems wherein the composition comprises a fluoroolefin and at least one other component. The compositions of the present invention are useful in processes for producing cooling or heat, as heat transfer fluids, foam blowing agents, aerosol propellants, and fire suppression and fire extinguishing agents.

2. Description of Related Art.

The refrigeration industry has been working for the past few decades to find replacement refrigerants for the ozone depleting chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) being phased out as a result of the Montreal Protocol. The solution for most refrigerant producers has been the commercialization of hydrofluorocarbon (HFC) refrigerants. The new HFC refrigerants, HFC-134a being the most widely used at this time, have zero ozone depletion potential and thus are not affected by the current regulatory phase out as a result of the Montreal Protocol.

Further environmental regulations may ultimately cause global phase out of certain HFC refrigerants. Currently, the automobile industry is facing regulations relating to global warming potential for refrigerants used in mobile air-conditioning. Therefore, there is a great current need to identify new refrigerants with reduced global warming potential for the mobile air-conditioning market. Should the regulations be more broadly applied in the future, an even greater need will be felt for refrigerants that can be used in all areas of the refrigeration and air-conditioning industry.

Currently proposed replacement refrigerants for HFC-134a include HFC-152a, pure hydrocarbons such as butane or propane, or “natural” refrigerants such as CO_2. Many of these suggested replacements are toxic, flammable, and/or have low energy efficiency. Therefore, new alternative refrigerants are being sought.

An aspect of the present invention is to provide novel refrigerant compositions and heat transfer fluid compositions that provide unique characteristics to meet the demands of low or zero ozone depletion potential and lower global warming potential as compared to current refrigerants.

BRIEF SUMMARY OF THE INVENTION

The present invention relates to a composition comprising an azeotropic or near azeotropic composition selected from the group consisting of:

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-1234yf;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-1243zf;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-134;

about 1 weight percent to about 52 weight percent trans-HFC-1234ze and about 99 weight percent to about 48 weight percent HFC-161 and about 87 weight percent to about 99 weight percent trans-HFC-1234ze and about 13 weight percent to about 1 weight percent HFC-161;

about 54 weight percent to about 99 weight percent trans-HFC-1234ze and about 46 weight percent to about 1 weight percent HFC-236ea;

about 44 weight percent to about 99 weight percent trans-HFC-1234ze and about 56 weight percent to about 1 weight percent HFC-236fa;

about 67 weight percent to about 99 weight percent trans-HFC-1234ze and about 33 weight percent to about 1 weight percent HFC-245fa;

about 1 weight percent to about 71 weight percent trans-HFC-1234ze and about 99 weight percent to about 29 weight percent propane;

about 62 weight percent to about 99 weight percent trans-HFC-1234ze and about 38 weight percent to about 1 weight percent n-butane;

about 39 weight percent to about 99 weight percent trans-HFC-1234ze and about 61 weight percent to about 1 weight percent isobutane;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent dimethylether;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent bis(trifluorometHy)sulfide;

about 80 weight percent to about 98 weight percent HFC-125, about 1 weight percent to about 19 weight percent trans-HFC-1234ze and about 1 weight percent to about 10 weight percent isobutane;

about 1 weight percent to about 98 weight percent HFC-32, about 1 weight percent to about 98 weight percent HFC-125, and about 1 weight percent to about 5 weight percent trans-HFC-1234ze;

about 80 weight percent to about 98 weight percent HFC-125, about 1 weight percent to about 19 weight percent trans-HFC-1234ze and about 1 weight percent to about 10 weight percent n-butane;

about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-1234ye;

about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-236ea;

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about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-236fa;

about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-245fa;

about 1 weight percent to about 80 weight percent cis-HFC-1234ze and about 99 weight percent to about 20 weight percent n-butane;

about 1 weight percent to about 69 weight percent cis-HFC-1234ze and about 99 weight percent to about 31 weight percent isobutane;

about 60 weight percent to about 99 weight percent cis-HFC-1234ze and about 40 weight percent to about 1 weight percent 2-methylbutane;

about 63 weight percent to about 99 weight percent cis-HFC-1234ze and about 37 weight percent to about 1 weight percent n-pentane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 98 weight percent HFC-227ea;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 30 weight percent n-butane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 40 weight percent isobutane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent

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HFC-134 and about 1 weight percent to about 98 weight percent HFC-152a;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-134 and about 1 weight percent to about 98 weight percent HFC-227ea;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-134 and about 1 weight percent to about 40 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-152a and about 1 weight percent to about 50 weight percent n-butane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-152a and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-227ea and about 1 weight percent to about 40 weight percent n-butane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 40 weight percent n-butane and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 60 weight percent isobutane and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 40 weight percent isobutane and about 1 weight percent to about 98 weight percent CF_3SCF_3;

9.5 weight percent trans-HFC-1234ze and 90.5 weight percent HFC-134a having a vapor pressure of about 15.5 psia (107 kPa) at a temperature of about -25 °C;

21.6 weight percent trans-HFC-1234ze and 78.4 weight percent HFC-152a having a vapor pressure of about 14.6 psia (101 kPa) at a temperature of about -25 °C; and

59.2 weight percent trans-HFC-1234ze and 40.8 weight percent HFC-227ea having a vapor pressure of about 11.7 psia (81 kPa) at a temperature of about -25 °C.

The present invention relates to, in one preferred embodiment, a composition comprising an azeotropic composition selected from the group consisting of:

17.0 weight percent trans-HFC-1234ze and 83.0 weight percent HFC-1243zf having a vapor pressure of about 13.0 psia (90 kPa) at a temperature of about -25 °C;

45.7 weight percent trans-HFC-1234ze and 54.3 weight percent HFC-134 having a vapor pressure of about 12.5 psia (86 kPa) at a temperature of about -25 °C;

28.5 weight percent trans-HFC-1234ze and 71.5 weight percent propane having a vapor pressure of about 30.3 psia (209 kPa) at a temperature of about -25 °C;

88.6 weight percent trans-HFC-1234ze and 11.4 weight percent n-butane having a vapor pressure of about 11.9 psia (82 kPa) at a temperature of about -25 °C;

77.9 weight percent trans-HFC-1234ze and 22.1 weight percent isobutane having a vapor pressure of about 12.9 psia (89 kPa) at a temperature of about -25 °C;

84.1 weight percent trans-HFC-1234ze and 15.9 weight percent dimethylether having a vapor pressure of about 10.8 psia (74 kPa) at a temperature of about -25 °C;

34.3 weight percent trans-HFC-1234ze and 65.7 weight percent CF_3SCF_3 having a vapor pressure of about 12.7 psia (88 kPa) at a temperature of about -25 °C;

7.1 weight percent trans-HFC-1234ze, 73.7 weight percent HFC-1243zf, and 19.2 weight percent HFC-227ea having a vapor pressure of about 13.1 psia (90.4 kPa) at a temperature of about -25 °C;

9.5 weight percent trans-HFC-1234ze, 81.2 weight percent HFC-1243zf, and 9.3 weight percent n-butane having a vapor

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pressure of about 13.5 psia (92.9 kPa) at a temperature of about -25 °C;

3.3 weight percent trans-HFC-1234ze, 77.6 weight percent HFC-1243zf, and 19.1 weight percent isobutane having a vapor pressure of about 14.3 psia (98.3 kPa) at a temperature of about -25 °C;

2.6 weight percent trans-HFC-1234ze, 70.0 weight percent HFC-1243zf, and 27.4 weight percent dimethylether having a vapor pressure of about 12.0 psia (82.9 kPa) at a temperature of about -25 °C;

52.0 weight percent trans-HFC-1234ze, 42.9 weight percent HFC-134, and 5.1 weight percent HFC-152a having a vapor pressure of about 12.4 psia (85.3 kPa) at a temperature of about -25 °C;

30.0 weight percent trans-HFC-1234ze, 43.2 weight percent HFC-134, and 26.8 weight percent HFC-227ea having a vapor pressure of about 12.6 psia (86.9 kPa) at a temperature of about -25 °C;

27.7 weight percent trans-HFC-1234ze, 54.7 weight percent HFC-134, and 17.7 weight percent dimethylether having a vapor pressure of about 9.8 psia (67.3 kPa) at a temperature of about -25 °C;

5.4 weight percent trans-HFC-1234ze, 80.5 weight percent HFC-152a, and 14.1 weight percent n-butane having a vapor pressure of about 15.4 psia (106 kPa) at a temperature of about -25 °C;

59.1 weight percent trans-HFC-1234ze, 16.4 weight percent HFC-152a, and 24.5 weight percent dimethylether having a vapor pressure of about 10.8 psia (74.5 kPa) at a temperature of about -25 °C;

40.1 weight percent trans-HFC-1234ze, 48.5 weight percent HFC-227ea, and 11.3 weight percent n-butane having a vapor pressure of about 12.6 psia (86.9 kPa) at a temperature of about -25 °C;

68.1 weight percent trans-HFC-1234ze, 13.0 weight percent n-butane, and 18.9 weight percent dimethylether having a vapor pressure of about 11.3 psia (77.8 kPa) at a temperature of about -25 °C;

55.5 weight percent trans-HFC-1234ze, 28.7 weight percent isobutane, and 15.8 weight percent dimethylether having a vapor pressure of about 12.4 psia (85.4 kPa) at a temperature of about -25 °C;

37.7 weight percent trans-HFC-1234ze, 1.1 weight percent isobutane, and 61.7 weight percent CF_3SCF_3 having a vapor pressure of about 12.7 psia (87.3 kPa) at a temperature of about -25 °C;

20.9 weight percent cis-HFC-1234ze and 79.1 weight percent HFC-236ea having a vapor pressure of about 30.3 psia (209 kPa) at a temperature of about 25 °C;

76.2 weight percent cis-HFC-1234ze and 23.8 weight percent HFC-245fa having a vapor pressure of about 26.1 psia (180 kPa) at a temperature of about 25 °C;

51.4 weight percent cis-HFC-1234ze and 48.6 weight percent n-butane having a vapor pressure of about 6.1 psia (41.9 kPa) at a temperature of about -25 °C;

26.2 weight percent cis-HFC-1234ze and 73.8 weight percent isobutane having a vapor pressure of about 8.7 psia (60.3 kPa) at a temperature of about -25 °C;

86.6 weight percent cis-HFC-1234ze and 13.4 weight percent 2-methylbutane having a vapor pressure of about 27.2 psia (188 kPa) at a temperature of about 25 °C; and

92.9 weight percent cis-HFC-1234ze and 7.1 weight percent n-pentane having a vapor pressure of about 26.2 psia (181 kPa) at a temperature of about 25 °C.

The present invention relates to, in one preferred embodiment, a composition further comprising a lubricant selected from the group consisting of polyol esters, polyalkylene glycols, polyvinyl ethers, mineral oil, alkylbenzenes, synthetic paraffins, synthetic napthenes, and poly(alpha)olefins.

The present invention relates to, in one preferred embodiment, a composition further comprising a tracer selected from the group consisting of hydrofluorocarbons, deuterated hydrocarbons, deuterated hydrofluorocarbons, perfluorocarbons, fluoroethers, brominated compounds, iodated compounds, alcohols, aldehydes, ketones, nitrous oxide (N_2O) and combinations thereof.

The present invention relates to, in one preferred embodiment, a composition further comprising a compatibilizer selected from the group consisting of:

a) polyoxyalkylene glycol ethers represented by the formula $R^1[(OR^2)_xOR^3]_y$, wherein: x is an integer from 1 to 3; y is an integer from 1 to 4; R^1 is selected from hydrogen and aliphatic hydrocarbon radicals having 1 to 6 carbon atoms and y bonding sites; R^2 is selected from aliphatic hydrocarbylene radicals having from 2 to 4 carbon atoms; R^3 is selected from hydrogen, and aliphatic and alicyclic hydrocarbon radicals having from 1 to 6 carbon atoms; at least one of R^1 and R^3 is selected from said hydrocarbon radicals; and wherein said polyoxyalkylene glycol ethers have a molecular weight of from about 100 to about 300 atomic mass units;

b) amides represented by the formulae $R^1C(O)NR^2R^3$ and cyclo-$[R^4CON(R^5)-]$, wherein R^1, R^2, R^3 and R^5 are independently selected from aliphatic and alicyclic hydrocarbon radicals having from 1 to 12 carbon atoms, and at most one aromatic radical having from 6 to 12 carbon atoms; R^4 is selected from aliphatic hydrocarbylene radicals having from 3 to 12 carbon atoms; and wherein said amides have a molecular weight of from about 100 to about 300 atomic mass units;

c) ketones represented by the formula $R^1C(O)R^2$, wherein R^1 and R^2 are independently selected from aliphatic, alicyclic and aryl hydrocarbon radicals having from 1 to 12 carbon atoms, and wherein said ketones have a molecular weight of from about 70 to about 300 atomic mass units;

d) nitriles represented by the formula R^1CN, wherein R^1 is selected from aliphatic, alicyclic or aryl hydrocarbon radicals having from 5 to 12 carbon atoms, and wherein said nitriles have a molecular weight of from about 90 to about 200 atomic mass units;

e) chlorocarbons represented by the formula RCl_x, wherein; x is 1 or 2; R is selected from aliphatic and alicyclic hydrocarbon radicals having from 1 to 12 carbon atoms; and wherein said

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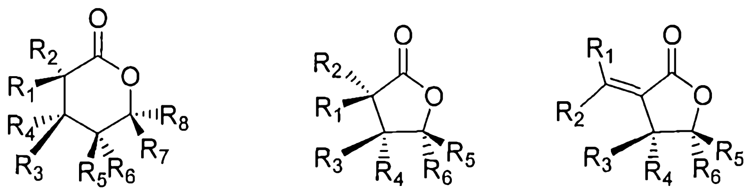
chlorocarbons have a molecular weight of from about 100 to about 200 atomic mass units;

f) aryl ethers represented by the formula R^1OR^2, wherein: R^1 is selected from aryl hydrocarbon radicals having from 6 to 12 carbon atoms; R^2 is selected from aliphatic hydrocarbon radicals having from 1 to 4 carbon atoms; and wherein said aryl ethers have a molecular weight of from about 100 to about 150 atomic mass units;

g) 1,1,1-trifluoroalkanes represented by the formula CF_3R^1, wherein R^1 is selected from aliphatic and alicyclic hydrocarbon radicals having from about 5 to about 15 carbon atoms;

h) fluoroethers represented by the formula $R^1OCF_2CF_2H$, wherein R^1 is selected from aliphatic, alicyclic, and aromatic hydrocarbon radicals having from about 5 to about 15 carbon atoms; or wherein said fluoroethers are derived from fluoroolefins and polyols, wherein said fluoroolefins are of the type $CF_2{=}CXY$, wherein X is hydrogen, chlorine or fluorine, and Y is chlorine, fluorine, CF_3 or OR_f, wherein R_f is CF_3, C_2F_5, or C_3F_7; and said polyols are linear or branched, wherein said linear polyols are of the type $HOCH_2(CHOH)_x(CRR')_yCH_2OH$, wherein R and R' are hydrogen, CH_3 or C_2H_5, x is an integer from 0-4, y is an integer from 0-3 and z is either zero or 1, and said branched polyols are of the type $C(OH)_t(R)_u(CH_2OH)_v[(CH_2)_mCH_2OH]_w$, wherein R may be hydrogen, CH_3 or C_2H_5, m is an integer from 0 to 3, t and u are 0 or 1, v and w are integers from 0 to 4, and also wherein t + u + v + w = 4; and

i) lactones represented by structures [B], [C], and [D]:



[B] [C] [D]

wherein, R_1 through R_8 are independently selected from hydrogen, linear, branched, cyclic, bicyclic, saturated and unsaturated hydrocarbyl radicals; and the molecular weight is from about 100 to about 300 atomic mass units; and

j) esters represented by the general formula $R^1CO_2R^2$, wherein R^1 and R^2 are independently selected from linear and cyclic, saturated and unsaturated, alkyl and aryl radicals; and wherein said esters have a molecular weight of from about 80 to about 550 atomic mass units.

The present invention relates to, in one preferred embodiment, a composition further comprising at least one ultra-violet fluorescent dye selected from the group consisting of naphthalimides, perylenes, coumarins, anthracenes, phenanthracenes, xanthenes, thioxanthenes, naphthoxanthenes, fluoresceins, derivatives of said dye and combinations thereof.

The present invention relates to, in one preferred embodiment, a composition further comprising at least one solubilizing agent selected from the group consisting of hydrocarbons, dimethylether, polyoxyalkylene glycol ethers, amides, ketones, nitriles, chlorocarbons, esters, lactones, aryl ethers, hydrofluoroethers, and 1,1,1-trifluoroalkanes.

The present invention relates to, in one preferred embodiment, a composition further comprising a stabilizer, water scavenger, or odor masking agent.

The present invention relates to, in one preferred embodiment, a composition wherein said stabilizer is selected from the group consisting of nitromethane, hindered phenols, hydroxylamines, thiols, phosphites and lactones.

The present invention further relates to a method of producing cooling, said method comprising: evaporating said composition as described herein in the vicinity of a body to be cooled and thereafter condensing said composition.

The present invention further relates to a method of producing heat, said method comprising: condensing said composition as described herein in the vicinity of a body to be heated and thereafter evaporating said composition.

The present invention further relates to a method for improving oil-return to the compressor in a compression refrigeration, air-conditioning or heat pump apparatus, said method comprising using the composition as described herein in said apparatus.

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The present invention further relates to a method for replacing a high global warming potential (GWP) refrigerant in a refrigeration, air-conditioning, or heat pump apparatus, wherein said high GWP refrigerant is selected from the group consisting of R134a, R22, R123, R11, R245fa, R114, R236fa, R124, R12, R410A, R407C, R417A, R422A, R507A, R502, and R404A, said method comprising providing the composition as described herein to said refrigeration, air-conditioning, or heat pump apparatus that uses, used or is designed to use said high GWP refrigerant.

The present invention further relates to a method of using the composition as described herein as a heat transfer fluid composition, said process comprising transporting said composition from a heat source to a heat sink.

The present invention further relates to a refrigeration, air-conditioning, or heat pump apparatus containing a composition as described herein.

The present invention further relates to the refrigeration, air-conditioning, or heat pump apparatus as described herein comprising a mobile air-conditioning apparatus.

The present invention further relates to a method of forming a foam comprising:

(a) adding to a foamable composition the composition as described herein; and

(b) reacting the foamable composition under conditions effective to form a foam.

The present invention further relates to a process for producing aerosol products comprising the step of adding a composition as described herein to active ingredients in an aerosol container, wherein said composition functions as a propellant.

DETAILED DESCRIPTION OF THE INVENTION

The present invention relates to compositions comprising at least one fluoroolefin. The compositions of the present invention further comprise at least one additional component that may be a second fluoroolefin, hydrofluorocarbon (HFC), hydrocarbon, dimethyl ether,

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bis(trifluoromethyl)sulfide, CF_3I, or CO_2. The fluoroolefin compounds and other components of the present inventive compositions are listed in Table 1.

TABLE 1

Compound	Chemical name	Chemical formula
HFC-1225ye	1,2,3,3,3-pentafluoropropene	$CF_3CF{=}CHF$
HFC-1234ze	1,3,3,3-tetrafluoropropene	$CF_3CH{=}CHF$
HFC-1234yf	2,3,3,3-tetrafluoropropene	$CF_3CF{=}CH_2$
HFC-1234ye	1,2,3,3-tetrafluoropropene	$CHF_2CF{=}CHF$
HFC-1243zf	3,3,3-trifluoropropene	$CF_3CH{=}CH_2$
HFC-32	difluoromethane	CH_2F_2
HFC-125	pentafluoroethane	CF_3CHF_2
HFC-134	1,1,2,2-tetrafluoroethane	CHF_2CHF_2
HFC-134a	1,1,1,2-tetrafluoroethane	CH_2FCF_3
HFC-143a	1,1,1-trifluoroethane	CH_3CF_3
HFC-152a	1,1-difluoroethane	CHF_2CH_3
HFC-161	fluoroethane	CH_3CH_2F
HFC-227ea	1,1,1,2,3,3,3-heptafluoropropane	CF_3CHFCF_3
HFC-236ea	1,1,1,2,3,3-hexafluoropropane	$CF_3CHFCHF_2$
HFC-236fa	1,1,1,3,3,3-hexafluoroethane	$CF_3CH_2CF_3$
HFC-245fa	1,1,1,3,3-pentafluoropropane	$CF_3CH_2CHF_2$
HFC-365mfc	1,1,1,3,3-pentafluorobutane	$CF_3CH_2CH_2CHF_2$
	propane	$CH_3CH_2CH_3$
	n-butane	$CH_3CH_2CH_2CH_3$
i-butane	isobutane	$CH_3CH(CH_3)CH_3$
	2-methylbutane	$CH_3CH(CH_3)CH_2CH_3$

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	n-pentane	$CH_3CH_2CH_2CH_2CH_3$
	cyclopentane	cyclo-$(CH_2)_5$-
DME	dimethylether	CH_3OCH_3
CO_2	carbon dioxide	CO_2
CF_3SCF_3	bis(trifluoromethyl)sulfide	CF_3SCF_3
	iodotrifluoromethane	CF_3I

The individual components listed in Table 1 may be prepared by methods known in the art.

The fluoroolefin compounds used in the compositions of the present invention, HFC-1225ye, HFC-1234ze, and HFC-1234ye, may exist as different configurational isomers or stereoisomers. The present invention is intended to include all single configurational isomers, single stereoisomers or any combination or mixture thereof. For instance, 1,3,3,3-tetra-fluoropropene (HFC-1234ze) is meant to represent the cis-isomer, trans-isomer, or any combination or mixture of both isomers in any ratio. Another example is HFC-1225ye, by which is represented the cis-isomer, trans-isomer, or any combination or mixture of both isomers in any ratio.

The compositions of the present invention include the following:

HFC-1225ye and at least one compound selected from the group consisting of HFC-1234ze, HFC-1234yf, HFC-1234ye, HFC-1243zf, HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143a, HFC-152a, HFC-161, HFC-227ea, HFC-236ea, HFC-236fa, HFC-245fa, HFC-365mfc, propane, n-butane, isobutane, 2-methylbutane, n-pentane, cyclopentane, dimethylether, CF_3SCF_3, CO_2 and CF_3I;

HFC-1234ze and at least one compound selected from the group consisting HFC-1225ye, HFC-1234yf, HFC-1234ye, HFC-1243zf, HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143a, HFC-152a, HFC-161, HFC-227ea, HFC-236ea, HFC-236fa, HFC-245fa, HFC-365mfc, propane, n-butane, isobutane, 2-methylbutane, n-pentane, cyclopentane, dimethylether, CF_3SCF_3, CO_2 and CF_3I;

HFC-1234yf and at least one compound selected from the group consisting of HFC-1234ye, HFC-1243zf, HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143a, HFC-152a, HFC-161, HFC-227ea, HFC-236ea, HFC-236fa, HFC-245fa, HFC-365mfc, propane, n-butane, isobutane, 2-

methylbutane, n-pentane, cyclopentane, dimethylether, CF_3SCF_3, CO_2 and CF_3I; and

HFC-1243zf and at least one compound selected from the group consisting of HFC-1234ye, HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143a, HFC-152a, HFC-161, HFC-227ea, HFC-236ea, HFC-236fa, HFC-245fa, HFC-365mfc, propane, n-butane, isobutane, 2-methylbutane, n-pentane, cyclopentane, dimethylether, CF_3SCF_3, CO_2 and CF_3I; and

HFC-1234ye and at least one compound selected from the group consisting of HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143a, HFC-152a, HFC-161, HFC-227ea, HFC-236ea, HFC-236fa, HFC-245fa, HFC-365mfc, propane, n-butane, isobutane, 2-methylbutane, n-pentane, cyclopentane, dimethylether, CF_3SCF_3, CO_2 and CF_3I.

The compositions of the present invention may be generally useful when the fluoroolefin is present at about 1 weight percent to about 99 weight percent, preferably about 20 weight percent to about 99 weight percent, more preferably about 40 weight percent to about 99 weight percent and still more preferably 50 weight percent to about 99 weight percent.

The present invention further provides compositions as listed in Table 2.

TABLE 2

Components	**Concentration ranges (wt%)**		
	Preferred	**More preferred**	**Most preferred**
HFC-1225ye/HFC-32	1-99/99-1	50-99/50-1	95/5 97/3
HFC-1225ye/HFC-134a	1-99/99-1	40-99/60-1	90/10
HFC-1225ye/CO_2	0.1-99.9/99.9-0.1	70-99.3/30-0.3	99/1
HFC-1225ye/HFC-1234yf	1-99/99-1	51-99/49-1	60/40
HFC-1225ye/HFC-152a/HFC-32	1-98/1-98/1-98	50-98/1-40/1-40	85/10/5 81/15/4 82/15/3
HFC-1225ye/HFC-152a/CO_2	1-98/1-98/0.1-98	50-98/1-40/0.3-30	84/15/1 84/15.5/0.5
HFC-1225ye/HFC-152a/propane	1-98/1-98/1-98	50-98/1-40/1-20	85/13/2
HFC-1225ye/HFC-152a/i-butane	1-98/1-98/1-98	50-98/1-40/1-20	85/13/2
HFC-1225ye/HFC-152a/DME	1-98/1-98/1-98	50-98/1-40/1-20	85/13/2

HFC-1225ye/HFC-134a/HFC-152a	1-98/1-98/1-98	40-98/1-50/1-40	76/9/15
HFC-1225ye/HFC-134a/HFC-32	1-98/1-98/1-98	20-98/1-50/1-40	88/9/3
HFC-1225ye/HFC-134a/HFC-161	1-98/1-98/1-98	40-98/1-50/1-20	86/10/4
HFC-1225ye/HFC-134a/CO_2	1-98/1-98/0.1-98	40-98/1-50/0.3-30	88.5/11/0.5
HFC-1225ye/HFC-134a/propane	1-98/1-98/1-98	40-98/1-50/1-20	87/10/3
HFC-1225ye/HFC-134a/i-butane	1-98/1-98/1-98	40-98/1-50/1-20	87/10/3
HFC-1225ye/HFC-134a/DME	1-98/1-98/1-98	40-98/1-50/1-20	87/10/3
HFC-1225ye/HFC-134/HFC-32	1-98/1-98/1-98	40-98/1-50/1-40	88/9/3
trans-HFC-1234ze/HFC-134a	1-99/99-1	30-99/70-1	90/10
trans-HFC-1234ze/HFC-32	1-99/99-1	40-99/60-1	95/5
trans-HFC-1234ze/HFC-152a	1-99/99-1	40-99/60-1	80/20
HFC-1234yf/HFC-134a	1-99/99-1	30-99/70-1	90/10
HFC-1234yf/HFC-32	1-99/99-1	40-99/60-1	95/5
HFC-1234yf/HFC-152a	1-99/99-1	40-99/60-1	80/20
HFC-1225ye/HFC-134a/HFC-152a/HFC-32	1-97/1-97/1-97/0.1-97	20-97/1-80/1-50/0.1-50	74/8/17/1
HFC-1225ye/HFC-1234yf/HFC-134a	1-98/1-98/0.1-98	10-90/10-90/0.1-50	70/20/10 and 20/70/20
HFC-1225ye/HFC-1234yf/HFC-32	1-98/1-98/0.1-98	10-90/10-90/0.1-50	25/73/2, 75/23/2, and 49/49/2
HFC-1225ye/HFC-1234yf/HFC-152a	1-98/1-98/0.1-98	10-90/10-90/0.1-50	70/25/5 and 25/70/5
HFC-1225ye/HFC-1234yf/HFC-125	1-98/1-98/0.1-98	10-90/10-90/0.1-50	25/71/4, 75/21/4, 75/24/1 and 25/74/1
HFC-1225ye/HFC-1234yf/ CF_3I	1-98/1-98/1-98	9-90/9-90/1-60	40/40/20 and 45/45/10
HFC-32/HFC-125/HFC-1225ye	0.1-98/0.1-98/0.1-98	5-70/5-70/5-70	30/30/40 and 23/25/52
HFC-32/HFC-125/trans-HFC-1234ze	0.1-98/0.1-98/0.1-98	5-70/5-70/5-70	30/50/20 and 23/25/52

HFC-32/HFC-125/HFC-1234yf	0.1-98/0.1-98/0.1-98	5-70/5-70/5-70	40/50/10, 23/25/52, 15/45/40, and 10/60/30
HFC-125/HFC-1225ye/n-butane	0.1-98/0.1-98/0.1-98	5-70/5-70/1-20	65/32/3 and 85.1/11.5/3.4
HFC-125/trans-HFC-1234ze/n-butane	0.1-98/0.1-98/0.1-98	5-70/5-70/1-20	66/32/2 and 86.1/11.5/2.4
HFC-125/HFC-1234yf/n-butane	0.1-98/0.1-98/0.1-98	5-70/5-70/1-20	67/32/1 and 87.1/11.5/1.4
HFC-125/HFC-1225ye/isobutane	0.1-98/0.1-98/0.1-98	5-70/5-70/1-20	85.1/11.5/3.4 and 65/32/3
HFC-125/trans-HFC-1234ze/isobutane	0.1-98/0.1-98/0.1-98	5-70/5-70/1-20	86.1/11.5/2.4 and 66/32/2
HFC-125/HFC-1234yf/isobutane	0.1-98/0.1-98/0.1-98	5-70/5-70/1-20	87.1/11.5/1.4 and 67/32/1
HFC-1234yf/HFC-32/HFC-143a	1-50/1-98/1-98	15-50/20-80/5-60	
HFC-1234yf/HFC-32/isobutane	1-40/59-98/1-30	10-40/59-90/1-10	
HFC-1234yf/HFC-125/HFC-143a	1-60/1-98/1-98	10-60/20-70/20-70	
HFC-1234yf/HFC-125/isobutane	1-40/59-98/1-20	10-40/59-90/1-10	
HFC-1234yf/HFC-134/propane	1-80/1-70/19-90	20-80/10-70/19-50	
HFC-1234yf/HFC-134/DME	1-70/1-98/29-98	20-70/10-70/29-50	
HFC-1234yf/HFC-134a/propane	1-80/1-80/19-98	10-80/10-80/19-50	
HFC-1234yf/HFC-134a/n-butane	1-98/1-98/1-30	10-80/10-80/1-20	
HFC-1234yf/HFC-134a/isobutane	1-98/1-98/1-30	10-80/10-80/1-20	
HFC-1234yf/HFC-134a/DME	1-98/1-98/1-40	10-80/10-80/1-20	
HFC-1234yf/HFC-143a/propane	1-80/1-98/1-98	10-80/10-80/1-50	
HFC-1234yf/HFC-143a/DME	1-40/59-98/1-20	5-40/59-90/1-10	
HFC-1234yf/HFC-152a/n-butane	1-98/1-98/1-30	10-80/10-80/1-20	
HFC-1234yf/HFC-152a/isobutane	1-98/1-90/1-40	10-80/10-80/1-20	
HFC-1234yf/HFC-152a/DME	1-70/1-98/1-98	10-70/10-80/1-20	
HFC-1234yf/HFC-227ea/propane	1-80/1-70/29-98	10-60/10-60/29-50	
HFC-1234yf/HFC-227ea/n-butane	40-98/1-59/1-20	50-98/10-49/1-10	
HFC-1234yf/HFC-227ea/isobutane	30-98/1-69/1-30	50-98/10-49/1-10	
HFC-1234yf/HFC-227ea/DME	1-98/1-80/1-98	10-80/10-80/1-20	

HFC-1234yf/n-butane/DME	1-98/1-40/1-98	10-80/10-40/1-20	
HFC-1234yf/isobutane/DME	1-98/1-50/1-98	10-90/1-40/1-20	
HFC-1234yf/DME/CF_3I	1-98/1-98/1-98	10-80/1-20/10-80	
HFC-1234yf/DME/CF_3SCF_3	1-98/1-40/1-80	10-80/1-20/10-70	
HFC-1225ye/trans-HFC-1234ze/HFC-134	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1225ye/trans-HFC-1234ze/HFC-227ea	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1225ye/trans-HFC-1234ze/propane	1-60/1-60/39-98	10-60/10-60/39-80	
HFC-1225ye/trans-HFC-1234ze/n-butane	1-98/1-98/1-30	10-80/10-80/1-20	
HFC-1225ye/trans-HFC-1234ze/DME	1-98/1-98/1-98	10-80/10-80/1-30	
HFC-1225ye/trans-HFC-1234ze/CF_3SCF_3	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1225ye/HFC-1243zf/HFC-134	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1225ye/HFC-1243zf/n-butane	1-98/1-98/1-30	10-80/10-80/1-20	
HFC-1225ye/HFC-1243zf/isobutane	1-98/1-98/1-40	10-80/10-80/1-30	
HFC-1225ye/HFC-1243zf/DME	1-98/1-98/1-98	10-80/10-80/1-30	
HFC-1225ye/HFC-1243zf/CF_3I	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1225ye/HFC-134/HFC-152a	1-98/1-98/1-98	10-80/10-80/1-50	
HFC-1225ye/HFC-134/HFC-227ea	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1225ye/HFC-134/n-butane	1-98/1-90/1-40	10-80/10-80/1-30	
HFC-1225ye/HFC-134/isobutane	1-98/1-90/1-40	10-80/10-80/1-30	
HFC-1225ye/HFC-134/DME	1-98/1-98/1-40	10-80/10-80/1-30	
HFC-1225ye/HFC-227ea/DME	40-98/1-59/1-30	50-98/1-49/1-20	
HFC-1225ye/n-butane/DME	1-98/1-30/1-98	60-98/1-20/1-20	
HFC-1225ye/n-butane/CF_3SCF_3	1-98/1-20/1-98	10-80/1-10/10-80	
HFC-1225ye/isobutane/DME	1-98/1-60/1-98	40-90/1-30/1-30	
HFC-1225ye/isobutane/CF_3I	1-98/1-40/1-98	10-80/1-30/10-80	

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trans-HFC-1234ze/HFC-1243zf/HFC-227ea	1-98/1-98/1-98	10-80/10-80/10-80	
trans-HFC-1234ze/HFC-1243zf/n-butane	1-98/1-98/1-30	10-80/10-80/1-20	
trans-HFC-1234ze/HFC-1243zf/isobutane	1-98/1-98/1-40	10-80/10-80/1-30	
trans-HFC-1234ze/HFC-1243zf/DME	1-98/1-98/1-98	10-80/10-80/1-40	
trans-HFC-1234ze/HFC-134/HFC-152a	1-98/1-98/1-98	10-80/10-80/1-50	
trans-HFC-1234ze/HFC-134/HFC-227ea	1-98/1-98/1-98	10-80/10-80/10-80	
trans-HFC-1234ze/HFC-134/DME	1-98/1-98/1-40	10-80/10-80/1-30	
trans-HFC-1234ze/HFC-134a/HFC-152a	1-98/1-98/1-98	10-80/10-80/1-50	
trans-HFC-1234ze/HFC-152a/n-butane	1-98/1-98/1-50	10-80/10-80/1-30	
trans-HFC-1234ze/HFC-152a/DME	1-98/1-98/1-98	20-90/1-50/1-30	
trans-HFC-1234ze/HFC-227ea/n-butane	1-98/1-98/1-40	10-80/10-80/1-30	
trans-HFC-1234ze/n-butane/DME	1-98/1-40/1-98	10-90/1-30/1-30	
trans-HFC-1234ze/n-butane/CF_3I	1-98/1-30/1-98	10-80/1-20/10-80	
trans-HFC-1234ze/isobutane/DME	1-98/1-60/1-98	10-90/1-30/1-30	
trans-HFC-1234ze/isobutane/CF_3I	1-98/1-40/1-98	10-80/1-20/10-80	
trans-HFC-1234ze/isobutane/CF_3SCF_3	1-98/1-40/1-98	10-80/1-20/10-80	
HFC-1243zf/HFC-134/HFC-227ea	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1243zf/HFC-134/n-butane	1-98/1-98/1-40	10-80/10-80/1-30	
HFC-1243zf/HFC-134/DME	1-98/1-98/1-98	10-80/10-80/1-30	
HFC-1243zf/HFC-134/CF_3I	1-98/1-98/1-98	10-80/10-80/10-80	
HFC-1243zf/HFC-134a/HFC-152a	1-98/1-98/1-98	10-80/10-80/1-50	

HFC-1243zf/HFC-134a/n-butane	1-98/1-98/1-40	10-80/10-80/1-30	
HFC-1243zf/HFC-152a/propane	1-70/1-70/29-98	10-70/1-50/29-40	
HFC-1243zf/HFC-152a/n-butane	1-98/1-98/1-30	10-80/1-80/1-20	
HFC-1243zf/HFC-152a/isobutane	1-98/1-98/1-40	10-80/1-80/1-30	
HFC-1243zf/HFC-152a/DME	1-98/1-98/1-98	10-80/1-80/1-30	
HFC-1243zf/HFC-227ea/n-butane	1-98/1-98/1-40	10-80/1-80/1-30	
HFC-1243zf/HFC-227ea/isobutane	1-98/1-90/1-50	10-80/1-80/1-30	
HFC-1243zf/HFC-227ea/DME	1-98/1-80/1-90	10-80/1-80/1-30	
HFC-1243zf/n-butane/DME	1-98/1-40/1-98	10-90/1-30/1-30	
HFC-1243zf/isobutane/DME	1-98/1-60/1-98	10-90/1-30/1-30	
HFC-1243zf/isobutane/CF_3I	1-98/1-40/1-98	10-80/1-30/10-80	
HFC-1243zf/DME/CF_3SCF_3	1-98/1-40/1-90	10-80/1-30/10-80	
HFC-1225ye/HFC-32/CF_3I	1-98/1-98/1-98	5-80/1-70/1-80	
HFC-1225ye/HFC-1234yf/HFC-32/HFC-125	1-97/1-97/1-97/1-97/1-97	1-80/1-70/5-70/5-70	
HFC-1225ye/HFC-1234yf/HFC-32/HFC-134a	1-97/1-97/1-97/1-97/1-97	5-70/5-70/5-80/5-70	
HFC-1225ye/HFC-1234yf/HFC-32/HFC-125/CF_3I	1-96/1-96/1-96/1-96/1-96	1-70/1-60/1-70/1-60/1-60	
HFC-1225ye/HFC-32/HFC-125/HFC-152a	1-97/1-97/1-97/1-97/1-97	10-80/5-70/5-70/5-70	
HFC-1225ye/HFC-32/HFC-125/isobutane	1-97/1-97/1-97/1-97/1-97	5-70/5-70/5-70/1-30	
HFC-1225ye/HFC-32/HFC-125/propane	1-97/1-97/1-97/1-97/1-50	5-70/5-70/5-70/1-30	
HFC-1225ye/HFC-32/HFC-125/DME	1-97/1-97/1-97/1-97/1-50	5-70/5-70/5-70/1-30	
HFC-1225ye/HFC-32/CF_3I/DME	1-97/1-97/1-97/1-97/1-50	5-70/5-70/5-70/1-30	
HFC-125ye/HFC-32/HFC-125/CF_3I	1-97/1-97/1-97/1-97	10-80/5-70/5-70/1-80	
HFC-1234yf/HFC-32/CF_3I	1-98/1-98/1-98	10-80/1-70/1-80	
HFC-1234yf/HFC-32/HFC-134a/CF_3I	1-97/1-97/1-97/1-97	5-70/5-80/1-70/5-70	
HFC-1234yf/HFC-32/HFC-125	1-98/1-98/1-98	10-80/5-80/10-80	

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HFC-1234yf/HFC-32/HFC-125/CF3I	1-97/1-97/1-97/1-97	10-80/5-70/10-80/5-80	

The most preferred compositions of the present invention listed in Table 2 are generally expected to maintain the desired properties and functionality when the components are present in the concentrations as listed +/- 2 weight percent. The compositions containing CO_2 would be expected to maintain the desired properties and functionality when the CO_2 was present at the listed concentration +/- 0.2 weight percent.

The compositions of the present invention may be azeotropic or near-azeotropic compositions. By azeotropic composition is meant a constant-boiling mixture of two or more substances that behave as a single substance. One way to characterize an azeotropic composition is that the vapor produced by partial evaporation or distillation of the liquid has the same composition as the liquid from which it is evaporated or distilled, i.e., the mixture distills/refluxes without compositional change. Constant-boiling compositions are characterized as azeotropic because they exhibit either a maximum or minimum boiling point, as compared with that of the non-azeotropic mixture of the same compounds. An azeotropic composition will not fractionate within a refrigeration or air conditioning system during operation, which may reduce efficiency of the system. Additionally, an azeotropic composition will not fractionate upon leakage from a refrigeration or air conditioning system. In the situation where one component of a mixture is flammable, fractionation during leakage could lead to a flammable composition either within the system or outside of the system.

A near-azeotropic composition (also commonly referred to as an “azeotrope-like composition”) is a substantially constant boiling liquid admixture of two or more substances that behaves essentially as a single substance. One way to characterize a near-azeotropic composition is that the vapor produced by partial evaporation or distillation of the liquid has substantially the same composition as the liquid from which it was evaporated or distilled, that is, the admixture distills/refluxes without substantial composition change. Another way to characterize a near-azeotropic composition is that the bubble point vapor pressure and the dew point vapor pressure of the composition at a particular temperature are substantially the same. Herein, a composition is near-azeotropic if,

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after 50 weight percent of the composition is removed, such as by evaporation or boiling off, the difference in vapor pressure between the original composition and the composition remaining after 50 weight percent of the original composition has been removed is less than about 10 percent.

Azeotropic compositions of the present invention at a specified temperature are shown in Table 3.

TABLE 3

Component A	Component B	Wt% A	Wt% B	Psia	kPa	T(C)
HFC-1234yf	HFC-32	7.4	92.6	49.2	339	-25
HFC-1234yf	HFC-125	10.9	89.1	40.7	281	-25
HFC-1234yf	HFC-134a	70.4	29.6	18.4	127	-25
HFC-1234yf	HFC-152a	91.0	9.0	17.9	123	-25
HFC-1234yf	HFC-143a	17.3	82.7	39.5	272	-25
HFC-1234yf	HFC-227ea	84.6	15.4	18.0	124	-25
HFC-1234yf	propane	51.5	48.5	33.5	231	-25
HFC-1234yf	n-butane	98.1	1.9	17.9	123	-25
HFC-1234yf	isobutane	88.1	11.9	19.0	131	-25
HFC-1234yf	DME	53.5	46.5	13.1	90	-25
HFC-1225ye	trans-HFC-1234ze	63.0	37.0	11.7	81	-25
HFC-1225ye	HFC-1243zf	40.0	60.0	13.6	94	-25
HFC-1225ye	HFC-134	52.2	47.8	12.8	88	-25
HFC-1225ye	HFC-152a	7.3	92.7	14.5	100	-25
HFC-1225ye	propane	29.7	70.3	30.3	209	-25
HFC-1225ye	n-butane	89.5	10.5	12.3	85	-25
HFC-1225ye	isobutane	79.3	20.7	13.9	96	-25
HFC-1225ye	DME	82.1	17.9	10.8	74	-25
HFC-1225ye	CF_3SCF_3	37.0	63.0	12.4	85	-25
trans- HFC-1234ze	HFC-1243zf	17.0	83.0	13.0	90	-25
trans- HFC-1234ze	HFC-134	45.7	54.3	12.5	86	-25
trans- HFC-1234ze	HFC-134a	9.5	90.5	15.5	107	-25
trans- HFC-1234ze	HFC-152a	21.6	78.4	14.6	101	-25
trans- HFC-1234ze	HFC-227ea	59.2	40.8	11.7	81	-25
trans- HFC-1234ze	propane	28.5	71.5	30.3	209	-25
trans- HFC-1234ze	n-butane	88.6	11.4	11.9	82	-25
trans- HFC-1234ze	isobutane	77.9	22.1	12.9	89	-25
trans- HFC-1234ze	DME	84.1	15.9	10.8	74	-25
trans- HFC-1234ze	CF_3SCF_3	34.3	65.7	12.7	88	-25
HFC-1243zf	HFC-134	63.0	37.0	13.5	93	-25
HFC-1243zf	HFC-134A	25.1	74.9	15.9	110	-25
HFC-1243zf	HFC-152A	40.7	59.3	15.2	104	-25
HFC-1243zf	HFC-227ea	78.5	21.5	13.1	90	-25

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HFC-1243zf	propane	32.8	67.2	31.0	213	-25
HFC-1243zf	n-butane	90.3	9.7	13.5	93	-25
HFC-1243zf	isobutane	80.7	19.3	14.3	98	-25
HFC-1243zf	DME	72.7	27.3	12.0	83	-25
cis- HFC-1234ze	HFC-236ea	20.9	79.1	30.3	209	25
cis- HFC-1234ze	HFC-245fa	76.2	23.8	26.1	180	25
cis- HFC-1234ze	n-butane	51.4	48.6	6.08	42	-25
cis- HFC-1234ze	isobutane	26.2	73.8	8.74	60	-25
cis- HFC-1234ze	2-methylbutane	86.6	13.4	27.2	188	25
cis- HFC-1234ze	n-pentane	92.9	7.1	26.2	181	25
HFC-1234ye	HFC-236ea	24.0	76.0	3.35	23.1	-25
HFC-1234ye	HFC-245fa	42.5	57.5	22.8	157	25
HFC-1234ye	n-butane	41.2	58.8	38.0	262	25
HFC-1234ye	isobutane	16.4	83.6	50.9	351	25
HFC-1234ye	2-methylbutane	80.3	19.7	23.1	159	25
HFC-1234ye	n-pentane	87.7	12.3	21.8	150	25

Additionally, ternary azeotropes composition have been found as listed in Table 4.

TABLE 4

Component A	Component B	Component C	Wt% A	Wt% B	Wt% C	Pres (psi)	Pres (kPa)	Temp (°C)
HFC-1234yf	HFC-32	HFC-143A	3.9	74.3	21.8	50.02	345	-25
HFC-1234yf	HFC-32	isobutane	1.1	92.1	6.8	50.05	345	-25
HFC-1234yf	HFC-125	HFC-143A	14.4	43.5	42.1	38.62	266	-25
HFC-1234yf	HFC-125	isobutane	9.7	89.1	1.2	40.81	281	-25
HFC-1234yf	HFC-134	propane	4.3	39.1	56.7	34.30	236	-25
HFC-1234yf	HFC-134	DME	15.2	67.0	17.8	10.38	71.6	-25
HFC-1234yf	HFC-134a	propane	24.5	31.1	44.5	34.01	234	-25
HFC-1234yf	HFC-134a	n-butane	60.3	35.2	4.5	18.58	128	-25
HFC-1234yf	HFC-134a	isobutane	48.6	37.2	14.3	19.86	137	-25
HFC-1234yf	HFC-134a	DME	24.0	67.9	8.1	17.21	119	-25
HFC-1234yf	HFC-143a	propane	17.7	71.0	11.3	40.42	279	-25
HFC-1234yf	HFC-143a	DME	5.7	93.0	1.3	39.08	269	-25
HFC-1234yf	HFC-152a	n-butane	86.6	10.8	2.7	17.97	124	-25
HFC-1234yf	HFC-152a	isobutane	75.3	11.8	12.9	19.12	132	-25
HFC-1234yf	HFC-152a	DME	24.6	43.3	32.1	11.78	81.2	-25
HFC-1234yf	HFC-227ea	propane	35.6	17.8	46.7	33.84	233	-25
HFC-1234yf	HFC-227ea	n-butane	81.9	16.0	2.1	18.07	125	-25

HFC-1234yf	HFC-227ea	isobutane	70.2	18.2	11.6	19.27	133	-25
HFC-1234yf	HFC-227ea	DME	28.3	55.6	16.1	15.02	104	-25
HFC-1234yf	n-butane	DME	48.9	4.6	46.4	13.15	90.7	-25
HFC-1234yf	isobutane	DME	31.2	26.2	42.6	14.19	97.8	-25
HFC-1234yf	DME	CF_3I	16.3	10.0	73.7	15.65	108	-25
HFC-1234yf	DME	CF_3SCF_3	34.3	10.5	55.2	14.57	100	-25
HFC-1225ye	trans-HFC-1234ze	HFC-134	47.4	5.6	47.0	12.77	88.0	-25
HFC-1225ye	trans-HFC-1234ze	HFC-227ea	28.4	52.6	19.0	11.63	80.2	-25
HFC-1225ye	trans-HFC-1234ze	propane	20.9	9.1	70.0	30.36	209	-25
HFC-1225ye	trans-HFC-1234ze	n-butane	65.8	24.1	10.1	12.39	85.4	-25
HFC-1225ye	trans-HFC-1234ze	DME	41.0	40.1	18.9	10.98	75.7	-25
HFC-1225ye	trans-HFC-1234ze	CF_3SCF_3	1.0	33.7	65.2	12.66	87.3	-25
HFC-1225ye	HFC-1243zf	HFC-134	28.7	47.3	24.1	13.80	95.1	-25
HFC-1225ye	HFC-1243zf	n-butane	37.5	55.0	7.5	13.95	96.2	-25
HFC-1225ye	HFC-1243zf	isobutane	40.5	43.2	16.3	14.83	102	-25
HFC-1225ye	HFC-1243zf	DME	19.1	51.0	29.9	12.15	83.8	-25
HFC-1225ye	HFC-1243zf	CF_3I	10.3	27.3	62.3	14.05	96.9	-25
HFC-1225ye	HFC-134	HFC-152a	63.6	26.8	9.6	12.38	85.4	-25
HFC-1225ye	HFC-134	HFC-227ea	1.3	52.3	46.4	12.32	84.9	-25
HFC-1225ye	HFC-134	n-butane	18.1	67.1	14.9	14.54	100	-25
HFC-1225ye	HFC-134	isobutane	0.7	74.0	25.3	16.68	115	-25
HFC-1225ye	HFC-134	DME	29.8	52.5	17.8	9.78	67.4	-25
HFC-1225ye	HFC-227ea	DME	63.1	31.0	5.8	10.93	75.4	-25
HFC-1225ye	n-butane	DME	66.0	13.0	21.1	11.34	78.2	-25
HFC-1225ye	n-butane	CF_3SCF_3	71.3	5.6	23.0	12.25	84.5	-25
HFC-1225ye	isobutane	DME	49.9	29.7	20.4	12.83	88.5	-25
HFC-1225ye	isobutane	CF_3I	27.7	2.2	70.1	13.19	90.9	-25
trans-HFC-1234ze	HFC-1243zf	HFC-227ea	7.1	73.7	19.2	13.11	90.4	-25
trans-HFC-	HFC-1243zf	n-butane	9.5	81.2	9.3	13.48	92.9	-25

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1234ze								
trans-HFC-1234ze	HFC-1243zf	isobutane	3.3	77.6	19.1	14.26	98.3	-25
trans-HFC-1234ze	HFC-1243zf	DME	2.6	70.0	27.4	12.03	82.9	-25
trans-HFC-1234ze	HFC-134	HFC-152a	52.0	42.9	5.1	12.37	85.3	-25
trans-HFC-1234ze	HFC-134	HFC-227ea	30.0	43.2	26.8	12.61	86.9	-25
trans-HFC-1234ze	HFC-134	DME	27.7	54.7	17.7	9.76	67.3	-25
trans-HFC-1234ze	HFC-134a	HFC-152a	14.4	34.7	51.0	14.42	99.4	-25
trans-HFC-1234ze	HFC-152a	n-butane	5.4	80.5	14.1	15.41	106	-25
trans-HFC-1234ze	HFC-152a	DME	59.1	16.4	24.5	10.80	74.5	-25
trans-HFC-1234ze	HFC-227ea	n-butane	40.1	48.5	11.3	12.61	86.9	-25
trans-HFC-1234ze	n-butane	DME	68.1	13.0	18.9	11.29	77.8	-25
trans-HFC-1234ze	n-butane	CF_3I	81.2	9.7	9.1	11.87	81.8	-25
trans-HFC-1234ze	isobutane	DME	55.5	28.7	15.8	12.38	85.4	-25
trans-HFC-1234ze	isobutane	CF_3I	34.9	6.1	59.0	12.57	86.7	-25
trans-HFC-1234ze	isobutane	CF_3SCF_3	37.7	1.1	61.7	12.66	87.3	-25
HFC-1243zf	HFC-134	HFC-227ea	58.6	34.1	7.3	13.54	93.4	-25
HFC-1243zf	HFC-134	n-butane	27.5	58.7	13.9	14.72	101	-25
HFC-1243zf	HFC-134	DME	18.7	63.5	17.8	10.11	69.7	-25
HFC-1243zf	HFC-134	CF_3I	11.4	23.9	64.7	14.45	99.6	-25
HFC-1243zf	HFC-134a	HFC-152a	41.5	21.5	37.1	14.95	103	-25
HFC-1243zf	HFC-134A	n-butane	7.0	81.4	11.6	17.03	117	-25
HFC-1243zf	HFC-152a	propane	2.9	34.0	63.0	31.73	219	-25

HFC-1243zf	HFC-152a	n-butane	28.8	60.3	11.0	15.71	108	-25
HFC-1243zf	HFC-152a	isobutane	6.2	68.5	25.3	17.05	118	-25
HFC-1243zf	HFC-152a	DME	33.1	36.8	30.1	11.41	78.7	-25
HFC-1243zf	HFC-227ea	n-butane	62.0	28.4	9.6	13.67	94.3	-25
HFC-1243zf	HFC-227ea	isobutane	27.9	51.0	21.1	15.00	103	-25
HFC-1243zf	HFC-227ea	DME	48.1	44.8	7.2	12.78	88.1	-25
HFC-1243zf	n-butane	DME	60.3	10.1	29.6	12.28	84.7	-25
HFC-1243zf	isobutane	DME	47.1	26.9	25.9	13.16	90.7	-25
HFC-1243zf	isobutane	CF_3I	32.8	1.1	66.1	13.97	96.3	-25
HFC-1243zf	DME	CF_3SCF_3	41.1	2.3	56.6	13.60	93.8	-25

The near-azeotropic compositions of the present invention at a specified temperature are listed in Table 5.

TABLE 5

Component A	Component B	(wt% A/wt% B)	T(C)
HFC-1234yf	HFC-32	1-57/99-43	-25
HFC-1234yf	HFC-125	1-51/99-49	-25
HFC-1234yf	HFC-134	1-99/99-1	-25
HFC-1234yf	HFC-134a	1-99/99-1	-25
HFC-1234yf	HFC-152a	1-99/99-1	-25
HFC-1234yf	HFC-161	1-99/99-1	-25
HFC-1234yf	HFC-143a	1-60/99-40	-25
HFC-1234yf	HFC-227ea	29-99/71-1	-25
HFC-1234yf	HFC-236fa	66-99/34-1	-25
HFC-1234yf	HFC-1225ye	1-99/99-1	-25
HFC-1234yf	trans-HFC-1234ze	1-99/99-1	-25
HFC-1234yf	HFC-1243zf	1-99/99-1	-25
HFC-1234yf	propane	1-80/99-20	-25
HFC-1234yf	n-butane	71-99/29-1	-25
HFC-1234yf	isobutane	60-99/40-1	-25
HFC-1234yf	DME	1-99/99-1	-25
HFC-1225ye	trans-HFC-1234ze	1-99/99-1	-25
HFC-1225ye	HFC-1243zf	1-99/99-1	-25
HFC-1225ye	HFC-134	1-99/99-1	-25
HFC-1225ye	HFC-134a	1-99/99-1	-25
HFC-1225ye	HFC-152a	1-99/99-1	-25
HFC-1225ye	HFC-161	1-84/99-16, 90-99/10-1	-25
HFC-1225ye	HFC-227ea	1-99/99-1	-25
HFC-1225ye	HFC-236ea	57-99/43-1	-25
HFC-1225ye	HFC-236fa	48-99/52-1	-25
HFC-1225ye	HFC-245fa	70-99/30-1	-25

HFC-1225ye	propane	1-72/99-28	-25
HFC-1225ye	n-butane	65-99/35-1	-25
HFC-1225ye	isobutane	50-99/50-1	-25
HFC-1225ye	DME	1-99/99-1	-25
HFC-1225ye	CF_3I	1-99/99-1	-25
HFC-1225ye	CF_3SCF_3	1-99/99-1	-25
trans-HFC-1234ze	trans-HFC-1234ze	73-99/27-1	-25
trans-HFC-1234ze	HFC-1243zf	1-99/99-1	-25
trans-HFC-1234ze	HFC-134	1-99/99-1	-25
trans-HFC-1234ze	HFC-134a	1-99/99-1	-25
trans-HFC-1234ze	HFC-152a	1-99/99-1	-25
trans-HFC-1234ze	HFC-161	1-52/99-48, 87-99/13-1	-25
trans-HFC-1234ze	HFC-227ea	1-99/99-1	-25
trans-HFC-1234ze	HFC-236ea	54-99/46-1	-25
trans-HFC-1234ze	HFC-236fa	44-99/56-1	-25
trans-HFC-1234ze	HFC-245fa	67-99/33-1	-25
trans-HFC-1234ze	propane	1-71/99-29	-25
trans-HFC-1234ze	n-butane	62-99/38-1	-25
trans-HFC-1234ze	isobutane	39-99/61-1	-25
trans-HFC-1234ze	DME	1-99/99-1	-25
trans-HFC-1234ze	CF_3SCF_3	1-99/99-1	-25
trans-HFC-1234ze	CF_3I	1-99/99-1	-25
HFC-1243zf	HFC-134	1-99/99-1	-25
HFC-1243zf	HFC-134a	1-99/99-1	-25
HFC-1243zf	HFC-152a	1-99/99-1	-25
HFC-1243zf	HFC-161	1-99/99-1	-25
HFC-1243zf	HFC-227ea	1-99/99-1	-25
HFC-1243zf	HFC-236ea	53-99/47-1	-25
HFC-1243zf	HFC-236fa	49-99/51-1	-25
HFC-1243zf	HFC-245fa	66-99/34-1	-25
HFC-1243zf	propane	1-71/99-29	-25
HFC-1243zf	n-butane	62-99/38-1	-25
HFC-1243zf	isobutane	45-99/55-1	-25
HFC-1243zf	DME	1-99/99-1	-25
cis- HFC-1234ze	HFC-236ea	1-99/99-1	25
cis- HFC-1234ze	HFC-236fa	1-99/99-1	25
cis- HFC-1234ze	HFC-245fa	1-99/99-1	25
cis- HFC-1234ze	n-butane	1-80/99-20	-25
cis- HFC-1234ze	isobutane	1-69/99-31	-25
cis- HFC-1234ze	2-methylbutane	60-99/40-1	25
cis- HFC-1234ze	n-pentane	63-99/37-1	25
HFC-1234ye	HFC-134	38-99/62-1	25
HFC-1234ye	HFC-236ea	1-99/99-1	-25
HFC-1234ye	HFC-236fa	1-99/99-1	25
HFC-1234ye	HFC-245fa	1-99/99-1	25

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HFC-1234ye	cis-HFC-1234ze	1-99/99-1	25
HFC-1234ye	n-butane	1-78/99-22	25
HFC-1234ye	cyclopentane	70-99/30-1	25
HFC-1234ye	isobutane	1-68/99-32	25
HFC-1234ye	2-methylbutane	47-99/53-1	25
HFC-1234ye	n-pentane	57-99/43-1	25

Ternary and higher order near-azeotrope compositions comprising fluoroolefin have also been identified as listed in Table 6.

TABLE 6

Components	Near-azeotrope range (weight percent)	Temp (°C)
HFC-1225ye/HFC-134a/HFC-152a	1-98/1-98/1-98	25
HFC-1225ye/HFC-134a/HFC-161	1-98/1-98/1-98	25
HFC-1225ye/HFC-134a/isobutane	1-98/1-98/1-40	25
HFC-1225ye/HFC-134a/DME	1-98/1-98/1-20	25
HFC-1225ye/HFC-152a/isobutane	1-98/1-98/1-50	25
HFC-1225ye/HFC-152a/DME	1-98/1-98/1-98	25
HFC-1225ye/HFC-1234yf/HFC-134a	1-98/1-98/1-98	25
HFC-1225ye/HFC-1234yf/HFC-152a	1-98/1-98/1-98	25
HFC-1225ye/HFC-1234yf/HFC-125	1-98/1-98/1-20	25
HFC-1225ye/HFC-1234yf/CF_3I	1-98/1-98/1-98	25
HFC-1225ye/HFC-134a/HFC-152a/HFC-32	1-97/1-97/1-97/1-10	25
HFC-125/HFC-1225ye/isobutane	80-98/1-19/1-10	25
HFC-125/trans-HFC-1234ze/isobutane	80-98/1-19/1-10	25
HFC-125/HFC-1234yf/isobutane	80-98/1-19/1-10	25
HFC-32/HFC-125/HFC-1225ye	1-98/1-98/1-4	25
HFC-32/HFC-125//trans-HFC-1234ze	1-98/1-98/1-5	25
HFC-32/HFC-125/HFC-1234yf	1-98/1-98/1-55	25
HFC-125/trans-HFC-1234ze/n-butane	80-98/1-19/1-10	25
HFC-125/HFC-1234yf/n-butane	80-98/1-19/1-10	25
HFC-1234yf/HFC-32/HFC-143a	1-50/1-98/1-98	-25
HFC-1234yf/HFC-32/isobutane	1-40/59-98/1-30	-25
HFC-1234yf/HFC-125/HFC-143a	1-60/1-98/1-98	-25
HFC-1234yf/HFC-125/isobutane	1-40/59-98/1-20	-25

HFC-1234yf/HFC-134/propane	1-80/1-70/19-90	-25
HFC-1234yf/HFC-134/DME	1-70/1-98/29-98	-25
HFC-1234yf/HFC-134a/propane	1-80/1-80/19-98	-25
HFC-1234yf/HFC-134a/n-butane	1-98/1-98/1-30	-25
HFC-1234yf/HFC-134a/isobutane	1-98/1-98/1-30	-25
HFC-1234yf/HFC-134a/DME	1-98/1-98/1-40	-25
HFC-1234yf/HFC-143a/propane	1-80/1-98/1-98	-25
HFC-1234yf/HFC-143a/DME	1-40/59-98/1-20	-25
HFC-1234yf/HFC-152a/n-butane	1-98/1-98/1-30	-25
HFC-1234yf/HFC-152a/isobutane	1-98/1-90/1-40	-25
HFC-1234yf/HFC-152a/DME	1-70/1-98/1-98	-25
HFC-1234yf/HFC-227ea/propane	1-80/1-70/29-98	-25
HFC-1234yf/HFC-227ea/n-butane	40-98/1-59/1-20	-25
HFC-1234yf/HFC-227ea/isobutane	30-98/1-69/1-30	-25
HFC-1234yf/HFC-227ea/DME	1-98/1-80/1-98	-25
HFC-1234yf/n-butane/DME	1-98/1-40/1-98	-25
HFC-1234yf/isobutane/DME	1-98/1-50/1-98	-25
HFC-1234yf/DME/CF_3I	1-98/1-98/1-98	-25
HFC-1234yf/DME/CF_3SCF_3	1-98/1-40/1-80	-25
HFC-1225ye/trans-HFC-1234ze/HFC-134	1-98/1-98/1-98	-25
HFC-1225ye/trans-HFC-1234ze/HFC-227ea	1-98/1-98/1-98	-25
HFC-1225ye/trans-HFC-1234ze/propane	1-60/1-60/39-98	-25
HFC-1225ye/trans-HFC-1234ze/n-butane	1-98/1-98/1-30	-25
HFC-1225ye/trans-HFC-1234ze/DME	1-98/1-98/1-98	-25
HFC-1225ye/trans-HFC-1234ze/ CF_3SCF_3	1-98/1-98/1-98	-25
HFC-1225ye/HFC-1243zf/HFC-134	1-98/1-98/1-98	-25
HFC-1225ye/HFC-1243zf/n-butane	1-98/1-98/1-30	-25
HFC-1225ye/HFC-1243zf/isobutane	1-98/1-98/1-40	-25
HFC-1225ye/HFC-1243zf/DME	1-98/1-98/1-98	-25
HFC-1225ye/HFC-1243zf/CF_3I	1-98/1-98/1-98	-25
HFC-1225ye/HFC-134/HFC-152a	1-98/1-98/1-98	-25

HFC-1225ye/HFC-134/HFC-227ea	1-98/1-98/1-98	-25
HFC-1225ye/HFC-134/n-butane	1-98/1-90/1-40	-25
HFC-1225ye/HFC-134/isobutane	1-98/1-90/1-40	-25
HFC-1225ye/HFC-134/DME	1-98/1-98/1-40	-25
HFC-1225ye/HFC-227ea/DME	40-98/1-59/1-30	-25
HFC-1225ye/n-butane/DME	1-98/1-30/1-98	-25
HFC-1225ye/n-butane/CF_3SCF_3	1-98/1-20/1-98	-25
HFC-1225ye/isobutane/DME	1-98/1-60/1-98	-25
HFC-1225ye/isobutane/CF_3I	1-98/1-40/1-98	-25
trans-HFC-1234ze/HFC-1243zf/HFC-227ea	1-98/1-98/1-98	-25
trans-HFC-1234ze/HFC-1243zf/n-butane	1-98/1-98/1-30	-25
trans-HFC-1234ze/HFC-1243zf/isobutane	1-98/1-98/1-40	-25
trans-HFC-1234ze/HFC-1243zf/DME	1-98/1-98/1-98	-25
trans-HFC-1234ze/HFC-134/HFC-152a	1-98/1-98/1-98	-25
trans-HFC-1234ze/HFC-134/HFC-227ea	1-98/1-98/1-98	-25
trans-HFC-1234ze/HFC-134/DME	1-98/1-98/1-40	-25
trans-HFC-1234ze/HFC-134a/HFC-152a	1-98/1-98/1-98	-25
trans-HFC-1234ze/HFC-152a/n-butane	1-98/1-98/1-50	-25
trans-HFC-1234ze/HFC-152a/DME	1-98/1-98/1-98	-25
trans-HFC-1234ze/HFC-227ea/n-butane	1-98/1-98/1-40	-25
trans-HFC-1234ze/n-butane/DME	1-98/1-40/1-98	-25
trans-HFC-1234ze/n-butane/CF_3I	1-98/1-30/1-98	-25
trans-HFC-1234ze/isobutane/DME	1-98/1-60/1-98	-25
trans-HFC-1234ze/isobutane/ CF_3I	1-98/1-40/1-98	-25
trans-HFC-1234ze/isobutane/ CF_3SCF_3	1-98/1-40/1-98	-25
HFC-1243zf/HFC-134/HFC-227ea	1-98/1-98/1-98	-25
HFC-1243zf/HFC-134/n-butane	1-98/1-98/1-40	-25

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HFC-1243zf/HFC-134/DME	1-98/1-98/1-98	-25
HFC-1243zf/HFC-134/CF_3I	1-98/1-98/1-98	-25
HFC-1243zf/HFC-134a/HFC-152a	1-98/1-98/1-98	-25
HFC-1243zf/HFC-134a/n-butane	1-98/1-98/1-40	-25
HFC-1243zf/HFC-152a/propane	1-70/1-70/29-98	-25
HFC-1243zf/HFC-152a/n-butane	1-98/1-98/1-30	-25
HFC-1243zf/HFC-152a/isobutane	1-98/1-98/1-40	-25
HFC-1243zf/HFC-152a/DME	1-98/1-98/1-98	-25
HFC-1243zf/HFC-227ea/n-butane	1-98/1-98/1-40	-25
HFC-1243zf/HFC-227ea/isobutane	1-98/1-90/1-50	-25
HFC-1243zf/HFC-227ea/DME	1-98/1-80/1-90	-25
HFC-1243zf/n-butane/DME	1-98/1-40/1-98	-25
HFC-1243zf/isobutane/DME	1-98/1-60/1-98	-25
HFC-1243zf/isobutane/CF_3I	1-98/1-40/1-98	-25
HFC-1243zf/DME/CF_3SCF_3	1-98/1-40/1-90	-25

Certain of the compositions of the present invention are non-azeotropic compositions. Those compositions of the present invention falling within the preferred ranges of Table 2, but outside of the near-azeotropic ranges of Table 5 and Table 6 may be considered to be non-azeotropic.

A non-azeotropic composition may have certain advantages over azetropic or near azeotropic mixtures. A non-azeotropic composition is a mixture of two or more substances that behaves as a mixture rather than a single substance. One way to characterize a non-azeotropic composition is that the vapor produced by partial evaporation or distillation of the liquid has a substantially different composition as the liquid from which it was evaporated or distilled, that is, the admixture distills/refluxes with substantial composition change. Another way to characterize a non-azeotropic composition is that the bubble point vapor pressure and the dew point vapor pressure of the composition at a particular temperature are substantially different. Herein, a composition is non-azeotropic if, after 50 weight percent of the composition is removed, such as by evaporation or boiling off, the difference in vapor pressure between the original composition and the composition remaining after 50 weight percent of the original composition has been removed is greater than about 10 percent.

The compositions of the present invention may be prepared by any convenient method to combine the desired amounts of the individual components. A preferred method is to weigh the desired component amounts and thereafter combine the components in an appropriate vessel. Agitation may be used, if desired.

An alternative means for making compositions of the present invention may be a method for making a refrigerant blend composition, wherein said refrigerant blend composition comprises a composition as disclosed herein, said method comprising (i) reclaiming a volume of one or more components of a refrigerant composition from at least one refrigerant container, (ii) removing impurities sufficiently to enable reuse of said one or more of the reclaimed components, (iii) and optionally, combining all or part of said reclaimed volume of components with at least one additional refrigerant composition or component.

A refrigerant container may be any container in which is stored a refrigerant blend composition that has been used in a refrigeration apparatus, air-conditioning apparatus or heat pump apparatus. Said refrigerant container may be the refrigeration apparatus, air-conditioning apparatus or heat pump apparatus in which the refrigerant blend was used. Additionally, the refrigerant container may be a storage container for collecting reclaimed refrigerant blend components, including but not limited to pressurized gas cylinders.

Residual refrigerant means any amount of refrigerant blend or refrigerant blend component that may be moved out of the refrigerant container by any method known for transferring refrigerant blends or refrigerant blend components.

Impurities may be any component that is in the refrigerant blend or refrigerant blend component due to its use in a refrigeration apparatus, air-conditioning apparatus or heat pump apparatus. Such impurities include but are not limited to refrigeration lubricants, being those described earlier herein, particulates including but not limited to metal, metal salt or elastomer particles, that may have come out of the refrigeration apparatus, air-conditioning apparatus or heat pump apparatus, and any other contaminants that may adversely effect the performance of the refrigerant blend composition.

Such impurities may be removed sufficiently to allow reuse of the refrigerant blend or refrigerant blend component without adversely

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effecting the performance or equipment within which the refrigerant blend or refrigerant blend component will be used.

It may be necessary to provide additional refrigerant blend or refrigerant blend component to the residual refrigerant blend or refrigerant blend component in order to produce a composition that meets the specifications required for a given product. For instance, if a refrigerant blend has 3 components in a particular weight percentage range, it may be necessary to add one or more of the components in a given amount in order to restore the composition to within the specification limits.

Compositions of the present invention have zero or low ozone depletion potential and low global warming potential (GWP). Additionally, the compositions of the present invention will have global warming potentials that are less than many hydrofluorocarbon refrigerants currently in use. One aspect of the present invention is to provide a refrigerant with a global warming potential of less than 1000, less than 500, less than 150, less than 100, or less than 50. Another aspect of the present invention is to reduce the net GWP of refrigerant mixtures by adding fluoroolefins to said mixtures.

The compositions of the present invention may be useful as low global warming potential (GWP) replacements for currently used refrigerants, including but not limited to R134a (or HFC-134a, 1,1,1,2-tetrafluoroethane), R22 (or HCFC-22, chlorodifluoromethane), R123 (or HFC-123, 2,2-dichloro-1,1,1-trifluoroethane), R11 (CFC-11, fluorotrichloromethane), R12 (CFC-12, dichlorodifluoromethane), R245fa (or HFC-245fa, 1,1,1,3,3-pentafluoropropane), R114 (or CFC-114, 1,2-dichloro-1,1,2,2-tetrafluoroethane), R236fa (or HFC-236fa, 1,1,1,3,3,3-hexafluoropropane), R124 (or HCFC-124, 2-chloro-1,1,1,2-tetrafluoroethane), R407C (ASHRAE designation for a blend of 52 weight percent R134a, 25 weight percent R125 (pentafluoroethane), and 23 weight percent R32 (difluoromethane), R410A (ASHRAE designation for a blend of 50 weight percent R125 and 50 weight percent R32), R417A, (ASHRAE designation for a blend of 46.6 weight percent R125, 50.0 weight percent R134a, and 3.4 weight percent n-butane), R422A (ASHRAE designation for a blend of 85.1 weight percent R125, 11.5 weight percent R134a, and 3.4 weight percent isobutane), R404A, (ASHRAE designation for a blend of 44 weight percent R125, 52 weight percent R143a (1,1,1-trifluoroethane), and 4.0 weight percent R134a) and

R507A (ASHRAE designation for a blend of 50 weight percent R125 and 50 weight percent R143a). Additionally, the compositions of the present invention may be useful as replacements for R12 (CFC-12, dichlorodifluoromethane) or R502 (ASHRAE designation for a blend of 51.2 weight percent CFC-115 (chloropentafluoroethane) and 48.8 weight percent HCFC-22).

Often replacement refrigerants are most useful if capable of being used in the original refrigeration equipment designed for a different refrigerant. The compositions of the present invention may be useful as replacements for the above-mentioned refrigerants in original equipment. Additionally, the compositions of the present invention may be useful as replacements for the above mentioned refrigerants in equipment designed to use the above-mentioned refrigerants.

The compositions of the present invention may further comprise a lubricant.

Lubricants of the present invention comprise refrigeration lubricants, i.e. those lubricants suitable for use with refrigeration, air-conditioning, or heat pump apparatus. Among these lubricants are those conventionally used in compression refrigeration apparatus utilizing chlorofluorocarbon refrigerants. Such lubricants and their properties are discussed in the 1990 ASHRAE Handbook, Refrigeration Systems and Applications, chapter 8, titled "Lubricants in Refrigeration Systems", pages 8.1 through 8.21. Lubricants of the present invention may comprise those commonly known as “mineral oils” in the field of compression refrigeration lubrication. Mineral oils comprise paraffins (i.e. straight-chain and branched-carbon-chain, saturated hydrocarbons), naphthenes (i.e. cyclic paraffins) and aromatics (i.e. unsaturated, cyclic hydrocarbons containing one or more rings characterized by alternating double bonds). Lubricants of the present invention further comprise those commonly known as “synthetic oils” in the field of compression refrigeration lubrication. Synthetic oils comprise alkylaryls (i.e. linear and branched alkyl alkylbenzenes), synthetic paraffins and napthenes, and poly(alphaolefins). Representative conventional lubricants of the present invention are the commercially available BVM 100 N (paraffinic mineral oil sold by BVA Oils), Suniso® 3GS and Suniso® 5GS (naphthenic mineral oil sold by Crompton Co.), Sontex® 372LT (naphthenic mineral oil sold by Pennzoil), Calumet® RO-30 (naphthenic mineral oil sold by Calumet Lubricants), Zerol® 75, Zerol® 150 and Zerol® 500 (linear alkylbenzenes sold by Shrieve Chemicals) and HAB 22 (branched alkylbenzene sold by Nippon Oil).

Lubricants of the present invention further comprise those that have been designed for use with hydrofluorocarbon refrigerants and are miscible with refrigerants of the present invention under compression refrigeration, air-conditioning, or heat pump apparatus' operating conditions. Such lubricants and their properties are discussed in "Synthetic Lubricants and High-Performance Fluids", R. L. Shubkin, editor, Marcel Dekker, 1993. Such lubricants include, but are not limited to, polyol esters (POEs) such as Castrol® 100 (Castrol, United Kingdom), polyalkylene glycols (PAGs) such as RL-488A from Dow (Dow Chemical, Midland, Michigan), and polyvinyl ethers (PVEs). These lubricants are readily available from various commercial sources.

Lubricants of the present invention are selected by considering a given compressor's requirements and the environment to which the lubricant will be exposed. Lubricants of the present invention preferably have a kinematic viscosity of at least about 5 cs (centistokes) at 40°C.

Commonly used refrigeration system additives may optionally be added, as desired, to compositions of the present invention in order to enhance lubricity and system stability. These additives are generally known within the field of refrigeration compressor lubrication, and include anti wear agents, extreme pressure lubricants, corrosion and oxidation inhibitors, metal surface deactivators, free radical scavengers, foaming and antifoam control agents, leak detectants and the like. In general, these additives are present only in small amounts relative to the overall lubricant composition. They are typically used at concentrations of from less than about 0.1 % to as much as about 3 % of each additive. These additives are selected on the basis of the individual system requirements. Some typical examples of such additives may include, but are not limited to, lubrication enhancing additives, such as alkyl or aryl esters of phosphoric acid and of thiophosphates. Additionally, the metal dialkyl dithiophosphates (e.g. zinc dialkyl dithiophosphate or ZDDP, Lubrizol 1375) and other members of this family of chemicals may be used in compositions of the present invention. Other antiwear additives include natural product oils and assymetrical polyhydroxyl lubrication additives such as Synergol TMS (International Lubricants). Similarly, stabilizers

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such as anti oxidants, free radical scavengers, and water scavengers may be employed. Compounds in this category can include, but are not limited to, butylated hydroxy toluene (BHT) and epoxides.

The compositions of the present invention may further comprise about 0.01 weight percent to about 5 weight percent of an additive such as, for example, a stabilizer, free radical scavenger and/or antioxidant. Such additives include but are not limited to, nitromethane, hindered phenols, hydroxylamines, thiols, phosphites, or lactones. Single additives or combinations may be used.

The compositions of the present invention may further comprise about 0.01 weight percent to about 5 weight percent of a water scavenger (drying compound). Such water scavengers may comprise ortho esters such as trimethyl-, triethyl-, or tripropylortho formate.

The compositions of the present invention may further comprise a tracer selected from the group consisting of hydrofluorocarbons (HFCs), deuterated hydrocarbons, deuterated hydrofluorocarbons, perfluorocarbons, fluoroethers, brominated compounds, iodated compounds, alcohols, aldehydes, ketones, nitrous oxide (N_2O) and combinations thereof. The tracer compounds are added to the compositions in previously determined quantities to allow detection of any dilution, contamination or other alteration of the composition, as described in U. S. Patent application serial no. 11/062044, filed February 18, 2005.

Typical tracer compounds for use in the present compositions are listed in Table 7.

TABLE 7

Compound	**Structure**
Deuterated hydrocarbons and hydrofluorocarbons	
Ethane-d6	CD_3CD_3
Propane-d8	$CD_3CD_2CD_3$
HFC-32-d2	CD_2F_2
HFC-134a-d2	CD_2FCF_3
HFC-143a-d3	CD_3CF_3
HFC-125-d	CDF_2CF_3
HFC-227ea-d	CF_3CDFCF_3
HFC-227ca-d	$CF_3CF_2CDF_2$
HFC-134-d2	CDF_2CDF_2

HFC-236fa-d2	$CF_3CD_2CF_3$
HFC-245cb-d3	$CF_3CF_2CD_3$
HFC-263fb-d2*	$CF_3CD_2CH_3$
HFC-263fb-d3	$CF_2CH_2CD_3$
Fluoroethers	
HFOC-125E	CHF_2OCF_3
HFOC-134aE	CH_2FOCF_3
HFOC-143aE	CH_3OCF_3
HFOC-227eaE	$CF_3OCHFCF_3$
HFOC-236faE	$CF_3OCH_2CF_3$
HFOC-245faEβγ or HFOC-245faEαβ	$CHF_2OCH_2CF_3$ (or $CHF_2CH_2OCF_3$)
HFOC-245cbEβγ or HFOC-245cbαβ	$CH_3OCF_2CF_3$ (or $CH_3CF_2OCF_3$)
HFE-42-11mcc (or Freon® E1)	$CF_3CF_2CF_2OCHFCF_3$
Freon® E2	$CF_3CF_2CF_2OCF(CF3)CF_2OCHFCF_3$
Hydrofluorocarbons	
HFC-23	CHF_3
HFC-161	CH_3CH_2F
HFC-152a	CH_3CHF_2
HFC-134	CHF_2CHF_2
HFC-227ea	CF_3CHFCF_3
HFC-227ca	$CHF_2CF_2CF_3$
HFC-236cb	$CH_2FCF_2CF_3$
HFC-236ea	$CF_3CHFCHF_2$
HFC-236fa	$CF_3CH_2CF_3$
HFC-245cb	$CF_3CF_2CH_3$
HFC-245fa	$CHF_2CH_2CF_3$
HFC-254cb	$CHF_2CF_2CH_3$
HFC-254eb	CF_3CHFCH_3
HFC-263fb	$CF_3CH_2CH_3$
HFC-272ca	$CH_3CF_2CH_3$
HFC-281ea	CH_3CHFCH_3
HFC-281fa	$CH_2FCH_2CH_3$
HFC-329p	$CHF_2CF_2CF_2CF_3$
HFC-329mmz	$(CH_3)_2CHCF_3$

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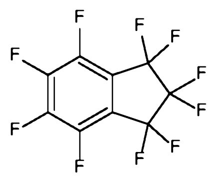
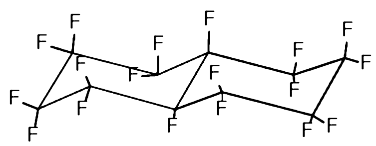
HFC-338mf	$CF_3CH_2CF_2CF_3$
HFC-338pcc	$CHF_2CF_2CF_2CHF_2$
HFC-347s	$CH_3CF_2CF_2CF_3$
HFC-43-10mee	$CF_3CHFCHFCF_2CF_3$
Perfluorocarbons	
PFC-116	CF_3CF_3
PFC-C216	Cyclo(-$CF_2CF_2CF_2$-)
PFC-218	$CF_3CF_2CF_3$
PFC-C318	Cyclo(-$CF_2CF_2CF_2CF_2$-)
PFC-31-10mc	$CF_3CF_2CF_2CF_3$
PFC-31-10my	$(CF_3)_2CFCF_3$
PFC-C51-12mycm	Cyclo(-$CF(CF_3)CF_2CF(CF_3)CF_2$-)
PFC-C51-12mym, trans	Cyclo(-$CF_2CF(CF_3)CF(CF_3CF_2$-)
PFC-C51-12mym, cis	Cyclo(-$CF_2CF(CF_3)CF(CF_3)CF_2$-)
Perfluoromethylcyclo-pentane	Cyclo(-$CF_2CF_2(CF_3)CF_2CF_2CF_2$-)
Perfluoromethylcyclo-hexane	Cyclo(-$CF_2CF_2(CF_3)CF_2CF_2CF_2CF_2$-)
Perfluorodimethylcyclo-hexane (ortho, meta, or para)	Cyclo(-$CF_2CF_2(CF_3)CF_2CF_2(CF_3)CF_2$-)
Perfluoroethylcyclohexane	Cyclo(-$CF_2CF_2(CF_2CF_3)CF_2CF_2CF_2CF_2$-)
Perfluoroindan	C_9F_{10} (see structure below)



Perfluorotrimethylcyclo-hexane (all possible isomers)	Cyclo(-$CF_2(CF_3)CF_2(CF_3)CF_2CF_2(CF_3)CF_2$-)
Perfluoroisopropylcyclo-hexane	Cyclo(-$CF_2CF_2(CF_2(CF_3)_2)CF_2CF_2CF_2CF_2$-)
Perfluorodecalin (cis or trans, trans shown)	$C_{10}F_{18}$ (see structure below)



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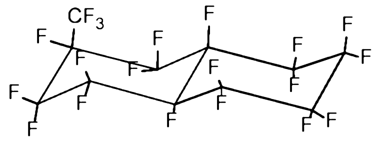
Perfluoromethyldecalin (cis or trans and all additional possible isomers)	$C_{11}F_{20}$ (see structure below)



Brominated compounds	
Bromomethane	CH_3Br
Bromofluoromethane	CH_2FBr
Bromodifluoromethane	CHF_2Br
Dibromofluoromethane	$CHFBr_2$
Tribromomethane	$CHBr_3$
Bromoethane	CH_3CH_2Br
Bromoethene	$CH_2=CHBr$
1,2-dibromoethane	CH_2BrCH_2Br
1-bromo-1,2-difluoroethene	$CFBr=CHF$
Iodated compounds	
Iodotrifluoromethane	CF_3I
Difluoroiodomethane	CHF_2I
Fluoroiodomethane	CH_2FI
1,1,2-trifluoro-1-iodoethane	CF_2ICH_2F
1,1,2,2-tetrafluoro-1-iodoethane	CF_2ICHF_2
1,1,2,2-tetrafluoro-1,2-diiodoethane	CF_2ICF_2I
Iodopentafluorobenzene	C_6F_5I
Alcohols	
Ethanol	CH_3CH_2OH
n-propanol	$CH_3CH_2CH_2OH$
Isopropanol	$CH_3CH(OH)CH_3$
Aldehydes and Ketones	
Acetone (2-propanone)	$CH_3C(O)CH_3$
n-propanal	CH_3CH_2CHO
n-butanal	$CH_3CH_2CH_2CHO$
Methyl ethyl ketone (2-butanone)	$CH_3C(O)CH_2CH_3$
Other	
Nitrous oxide	N_2O

The compounds listed in Table 7 are available commercially (from chemical supply houses) or may be prepared by processes known in the art.

Single tracer compounds may be used in combination with a refrigeration/heating fluid in the compositions of the present invention or multiple tracer compounds may be combined in any proportion to serve as a tracer blend. The tracer blend may contain multiple tracer compounds from the same class of compounds or multiple tracer compounds from different classes of compounds. For example, a tracer blend may contain 2 or more deuterated hydrofluorocarbons, or one deuterated hydrofluorocarbon in combination with one or more perfluorocarbons.

Additionally, some of the compounds in Table 7 exist as multiple isomers, structural or optical. Single isomers or multiple isomers of the same compound may be used in any proportion to prepare the tracer compound. Further, single or multiple isomers of a given compound may be combined in any proportion with any number of other compounds to serve as a tracer blend.

The tracer compound or tracer blend may be present in the compositions at a total concentration of about 50 parts per million by weight (ppm) to about 1000 ppm. Preferably, the tracer compound or tracer blend is present at a total concentration of about 50 ppm to about 500 ppm and most preferably, the tracer compound or tracer blend is present at a total concentration of about 100 ppm to about 300 ppm.

The compositions of the present invention may further comprise a compatibilizer selected from the group consisting of polyoxyalkylene glycol ethers, amides, nitriles, ketones, chlorocarbons, esters, lactones, aryl ethers, fluoroethers and 1,1,1-trifluoroalkanes. The compatibilizer is used to improve solubility of hydrofluorocarbon refrigerants in conventional refrigeration lubricants. Refrigeration lubricants are needed to lubricate the compressor of a refrigeration, air-conditioning or heat pump apparatus. The lubricant must move throughout the apparatus with the refrigerant in particular it must return from the non-compressor zones to the compressor to continue to function as lubricant and avoid compressor failure.

Hydrofluorocarbon refrigerants are generally not compatible with convention refrigeration lubricants such as mineral oils, alkylbenzenes, synthetic paraffins, synthetic napthenes and poly(alpha)olefins. Many replacement lubricants have been proposed, however, the polyalkylene

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glycols, polyol esters and polyvinyl ethers, suggested for use with hydrofluorocarbon refrigerants are expensive and absorb water readily. Water in a refrigeration, air-conditioning system or heat pump can lead to corrosion and the formation of particles that may plug the capillary tubes and other small orifices in the system, ultimately causing system failure. Additionally, in existing equipment, time-consuming and costly flushing procedures are required to change to a new lubricant. Therefore, it is desirable to continue to use the original lubricant if possible.

The compatibilizers of the present invention improve solubility of the hydrofluorocarbon refrigerants in conventional refrigeration lubricants and thus improve oil return to the compressor.

Polyoxyalkylene glycol ether compatibilizers of the present invention are represented by the formula $R^1[(OR^2)_xOR^3]_y$, wherein: x is an integer from 1-3; y is an integer from 1-4; R^1 is selected from hydrogen and aliphatic hydrocarbon radicals having 1 to 6 carbon atoms and y bonding sites; R^2 is selected from aliphatic hydrocarbylene radicals having from 2 to 4 carbon atoms; R^3 is selected from hydrogen and aliphatic and alicyclic hydrocarbon radicals having from 1 to 6 carbon atoms; at least one of R^1 and R^3 is said hydrocarbon radical; and wherein said polyoxyalkylene glycol ethers have a molecular weight of from about 100 to about 300 atomic mass units. As used herein, bonding sites mean radical sites available to form covalent bonds with other radicals. Hydrocarbylene radicals mean divalent hydrocarbon radicals. In the present invention, preferred polyoxyalkylene glycol ether compatibilizers are represented by $R^1[(OR^2)_xOR^3]_y$: x is preferably 1-2; y is preferably 1; R^1 and R^3 are preferably independently selected from hydrogen and aliphatic hydrocarbon radicals having 1 to 4 carbon atoms; R^2 is preferably selected from aliphatic hydrocarbylene radicals having from 2 or 3 carbon atoms, most preferably 3 carbon atoms; the polyoxyalkylene glycol ether molecular weight is preferably from about 100 to about 250 atomic mass units, most preferably from about 125 to about 250 atomic mass units. The R^1 and R^3 hydrocarbon radicals having 1 to 6 carbon atoms may be linear, branched or cyclic. Representative R^1 and R^3 hydrocarbon radicals include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *sec*-butyl, *tert*-butyl, pentyl, isopentyl, neopentyl, *tert*-pentyl, cyclopentyl, and cyclohexyl. Where free hydroxyl radicals on the present polyoxyalkylene glycol ether compatibilizers may be incompatible with certain compression refrigeration

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apparatus materials of construction (e.g. Mylar®), R^1 and R^3 are preferably aliphatic hydrocarbon radicals having 1 to 4 carbon atoms, most preferably 1 carbon atom. The R^2 aliphatic hydrocarbylene radicals having from 2 to 4 carbon atoms form repeating oxyalkylene radicals - $(OR^2)_x$ - that include oxyethylene radicals, oxypropylene radicals, and oxybutylene radicals. The oxyalkylene radical comprising R^2 in one polyoxyalkylene glycol ether compatibilizer molecule may be the same, or one molecule may contain different R^2 oxyalkylene groups. The present polyoxyalkylene glycol ether compatibilizers preferably comprise at least one oxypropylene radical. Where R^1 is an aliphatic or alicyclic hydrocarbon radical having 1 to 6 carbon atoms and y bonding sites, the radical may be linear, branched or cyclic. Representative R^1 aliphatic hydrocarbon radicals having two bonding sites include, for example, an ethylene radical, a propylene radical, a butylene radical, a pentylene radical, a hexylene radical, a cyclopentylene radical and a cyclohexylene radical. Representative R^1 aliphatic hydrocarbon radicals having three or four bonding sites include residues derived from polyalcohols, such as trimethylolpropane, glycerin, pentaerythritol, 1,2,3-trihydroxycyclohexane and 1,3,5-trihydroxycyclohexane, by removing their hydroxyl radicals.

Representative polyoxyalkylene glycol ether compatibilizers include but are not limited to: $CH_3OCH_2CH(CH_3)O(H$ or $CH_3)$ (propylene glycol methyl (or dimethyl) ether), $CH_3O[CH_2CH(CH_3)O]_2(H$ or $CH_3)$ (dipropylene glycol methyl (or dimethyl) ether), $CH_3O[CH_2CH(CH_3)O]_3(H$ or $CH_3)$ (tripropylene glycol methyl (or dimethyl) ether), $C_2H_5OCH_2CH(CH_3)O(H$ or $C_2H_5)$ (propylene glycol ethyl (or diethyl) ether), $C_2H_5O[CH_2CH(CH_3)O]_2(H$ or $C_2H_5)$ (dipropylene glycol ethyl (or diethyl) ether), $C_2H_5O[CH_2CH(CH_3)O]_3(H$ or $C_2H_5)$ (tripropylene glycol ethyl (or diethyl) ether), $C_3H_7OCH_2CH(CH_3)O(H$ or $C_3H_7)$ (propylene glycol n-propyl (or di-n-propyl) ether), $C_3H_7O[CH_2CH(CH_3)O]_2(H$ or $C_3H_7)$ (dipropylene glycol n-propyl (or di-n-propyl) ether) , $C_3H_7O[CH_2CH(CH_3)O]_3(H$ or $C_3H_7)$ (tripropylene glycol n-propyl (or di-n-propyl) ether), $C_4H_9OCH_2CH(CH_3)OH$ (propylene glycol n-butyl ether), $C_4H_9O[CH_2CH(CH_3)O]_2(H$ or $C_4H_9)$ (dipropylene glycol n-butyl (or di-n-butyl) ether), $C_4H_9O[CH_2CH(CH_3)O]_3(H$ or $C_4H_9)$ (tripropylene glycol n-butyl (or di-n-butyl) ether), $(CH_3)_3COCH_2CH(CH_3)OH$ (propylene glycol t-butyl ether), $(CH_3)_3CO[CH_2CH(CH_3)O]_2(H$ or $(CH_3)_3)$ (dipropylene glycol t-butyl (or di-t-butyl) ether), $(CH_3)_3CO[CH_2CH(CH_3)O]_3(H$ or $(CH_3)_3)$ (tripropylene glycol t-butyl (or di-t-butyl) ether), $C_5H_{11}OCH_2CH(CH_3)OH$ (propylene glycol n-pentyl ether), $C_4H_9OCH_2CH(C_2H_5)OH$ (butylene glycol n-butyl ether), $C_4H_9O[CH_2CH(C_2H_5)O]_2H$ (dibutylene glycol n-butyl ether), trimethylolpropane tri-n-butyl ether ($C_2H_5C(CH_2O(CH_2)_3CH_3)_3$) and trimethylolpropane di-n-butyl ether ($C_2H_5C(CH_2OC(CH_2)_3CH_3)_2CH_2OH$).

Amide compatibilizers of the present invention comprise those represented by the formulae $R^1C(O)NR^2R^3$ and cyclo-$[R^4C(O)N(R^5)]$, wherein R^1, R^2, R^3 and R^5 are independently selected from aliphatic and alicyclic hydrocarbon radicals having from 1 to 12 carbon atoms; R^4 is selected from aliphatic hydrocarbylene radicals having from 3 to 12 carbon atoms; and wherein said amides have a molecular weight of from about 100 to about 300 atomic mass units. The molecular weight of said amides is preferably from about 160 to about 250 atomic mass units. R^1, R^2, R^3 and R^5 may optionally include substituted hydrocarbon radicals, that is, radicals containing non-hydrocarbon substituents selected from halogens (e.g., fluorine, chlorine) and alkoxides (e.g. methoxy). R^1, R^2, R^3 and R^5 may optionally include heteroatom-substituted hydrocarbon radicals, that is, radicals, which contain the atoms nitrogen (aza-), oxygen (oxa-) or sulfur (thia-) in a radical chain otherwise composed of carbon atoms. In general, no more than three non-hydrocarbon substituents and heteroatoms, and preferably no more than one, will be present for each 10 carbon atoms in R^{1-3}, and the presence of any such non-hydrocarbon substituents and heteroatoms must be considered in applying the aforementioned molecular weight limitations. Preferred amide compatibilizers consist of carbon, hydrogen, nitrogen and oxygen. Representative R^1, R^2, R^3 and R^5 aliphatic and alicyclic hydrocarbon radicals include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *sec*-butyl, *tert*-butyl, pentyl, isopentyl, neopentyl, *tert*-pentyl, cyclopentyl, cyclohexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl and their configurational isomers. A preferred embodiment of amide compatibilizers are those wherein R^4 in the aforementioned formula cyclo-$[R^4C(O)N(R^5)\text{-}]$ may be represented by the hydrocarbylene radical $(CR^6R^7)_n$, in other words, the formula: cyclo-$[(CR^6R^7)_nC(O)N(R^5)\text{-}]$ wherein: the previously-stated values for molecular weight apply; n is an integer from 3 to 5; R^5 is a saturated hydrocarbon radical containing 1 to 12 carbon atoms; R^6 and R^7 are independently selected (for each n) by the rules previously offered defining R^{1-3}. In the lactams represented by the formula: cyclo-

[(CR^6R^7)$_n$C(O)N(R^5)-], all R^6 and R^7 are preferably hydrogen, or contain a single saturated hydrocarbon radical among the n methylene units, and R^5 is a saturated hydrocarbon radical containing 3 to 12 carbon atoms. For example, 1-(saturated hydrocarbon radical)-5-methylpyrrolidin-2-ones.

Representative amide compatibilizers include but are not limited to: 1-octylpyrrolidin-2-one, 1-decylpyrrolidin-2-one, 1-octyl-5-methylpyrrolidin-2-one, 1-butylcaprolactam, 1-cyclohexylpyrrolidin-2-one, 1-butyl-5-methylpiperid-2-one, 1-pentyl-5-methylpiperid-2-one, 1-hexylcaprolactam, 1-hexyl-5-methylpyrrolidin-2-one, 5-methyl-1-pentylpiperid-2-one, 1,3-dimethylpiperid-2-one, 1-methylcaprolactam, 1-butyl-pyrrolidin-2-one, 1,5-dimethylpiperid-2-one, 1-decyl-5-methylpyrrolidin-2-one, 1-dodecylpyrrolid-2-one, N,N-dibutylformamide and N,N-diisopropylacetamide.

Ketone compatibilizers of the present invention comprise ketones represented by the formula $R^1C(O)R^2$, wherein R^1 and R^2 are independently selected from aliphatic, alicyclic and aryl hydrocarbon radicals having from 1 to 12 carbon atoms, and wherein said ketones have a molecular weight of from about 70 to about 300 atomic mass units. R^1 and R^2 in said ketones are preferably independently selected from aliphatic and alicyclic hydrocarbon radicals having 1 to 9 carbon atoms. The molecular weight of said ketones is preferably from about 100 to 200 atomic mass units. R^1 and R^2 may together form a hydrocarbylene radical connected and forming a five, six, or seven-membered ring cyclic ketone, for example, cyclopentanone, cyclohexanone, and cycloheptanone. R^1 and R^2 may optionally include substituted hydrocarbon radicals, that is, radicals containing non-hydrocarbon substituents selected from halogens (e.g., fluorine, chlorine) and alkoxides (e.g. methoxy). R^1 and R^2 may optionally include heteroatom-substituted hydrocarbon radicals, that is, radicals, which contain the atoms nitrogen (aza-), oxygen (keto-, oxa-) or sulfur (thia-) in a radical chain otherwise composed of carbon atoms. In general, no more than three non-hydrocarbon substituents and heteroatoms, and preferably no more than one, will be present for each 10 carbon atoms in R^1 and R^2, and the presence of any such non-hydrocarbon substituents and heteroatoms must be considered in applying the aforementioned molecular weight limitations. Representative R^1 and R^2 aliphatic, alicyclic and aryl hydrocarbon radicals in the general formula $R^1C(O)R^2$ include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *sec*-butyl, *tert*-butyl, pentyl, isopentyl, neopentyl, *tert*-pentyl, cyclopentyl, cyclohexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl and their configurational isomers, as well as phenyl, benzyl, cumenyl, mesityl, tolyl, xylyl and phenethyl.

Representative ketone compatibilizers include but are not limited to: 2-butanone, 2-pentanone, acetophenone, butyrophenone, hexanophenone, cyclohexanone, cycloheptanone, 2-heptanone, 3-heptanone, 5-methyl-2-hexanone, 2-octanone, 3-octanone, diisobutyl ketone, 4-ethylcyclohexanone, 2-nonanone, 5-nonanone, 2-decanone, 4-decanone, 2-decalone, 2-tridecanone, dihexyl ketone and dicyclohexyl ketone.

Nitrile compatibilizers of the present invention comprise nitriles represented by the formula R^1CN, wherein R^1 is selected from aliphatic, alicyclic or aryl hydrocarbon radicals having from 5 to 12 carbon atoms, and wherein said nitriles have a molecular weight of from about 90 to about 200 atomic mass units. R^1 in said nitrile compatibilizers is preferably selected from aliphatic and alicyclic hydrocarbon radicals having 8 to 10 carbon atoms. The molecular weight of said nitrile compatibilizers is preferably from about 120 to about 140 atomic mass units. R^1 may optionally include substituted hydrocarbon radicals, that is, radicals containing non-hydrocarbon substituents selected from halogens (e.g., fluorine, chlorine) and alkoxides (e.g. methoxy). R^1 may optionally include heteroatom-substituted hydrocarbon radicals, that is, radicals, which contain the atoms nitrogen (aza-), oxygen (keto-, oxa-) or sulfur (thia-) in a radical chain otherwise composed of carbon atoms. In general, no more than three non-hydrocarbon substituents and heteroatoms, and preferably no more than one, will be present for each 10 carbon atoms in R^1, and the presence of any such non-hydrocarbon substituents and heteroatoms must be considered in applying the aforementioned molecular weight limitations. Representative R^1 aliphatic, alicyclic and aryl hydrocarbon radicals in the general formula R^1CN include pentyl, isopentyl, neopentyl, *tert*-pentyl, cyclopentyl, cyclohexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl and their configurational isomers, as well as phenyl, benzyl, cumenyl, mesityl, tolyl, xylyl and phenethyl.

Representative nitrile compatibilizers include but are not limited to: 1-cyanopentane, 2,2-dimethyl-4-cyanopentane, 1-cyanohexane, 1-cyanoheptane, 1-cyanooctane, 2-cyanooctane, 1-cyanononane, 1-cyanodecane, 2-cyanodecane, 1-cyanoundecane and 1-cyanododecane.

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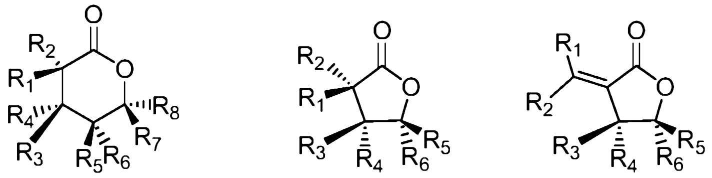
Chlorocarbon compatibilizers of the present invention comprise chlorocarbons represented by the formula RCl_x, wherein; x is selected from the integers 1 or 2; R is selected from aliphatic and alicyclic hydrocarbon radicals having 1 to 12 carbon atoms; and wherein said chlorocarbons have a molecular weight of from about 100 to about 200 atomic mass units. The molecular weight of said chlorocarbon compatibilizers is preferably from about 120 to 150 atomic mass units. Representative R aliphatic and alicyclic hydrocarbon radicals in the general formula RCl_x include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *sec*-butyl, *tert*-butyl, pentyl, isopentyl, neopentyl, *tert*-pentyl, cyclopentyl, cyclohexyl, heptyl, octyl, nonyl, decyl, undecyl, dodecyl and their configurational isomers.

Representative chlorocarbon compatibilizers include but are not limited to: 3-(chloromethyl)pentane, 3-chloro-3-methylpentane, 1-chlorohexane, 1,6-dichlorohexane, 1-chloroheptane, 1-chlorooctane, 1-chlorononane, 1-chlorodecane, and 1,1,1-trichlorodecane.

Ester compatibilizers of the present invention comprise esters represented by the general formula $R^1CO_2R^2$, wherein R^1 and R^2 are independently selected from linear and cyclic, saturated and unsaturated, alkyl and aryl radicals. Preferred esters consist essentially of the elements C, H and O, have a molecular weight of from about 80 to about 550 atomic mass units.

Representative esters include but are not limited to: $(CH_3)_2CHCH_2OOC(CH_2)_{2\text{-}4}OCOCH_2CH(CH_3)_2$ (diisobutyl dibasic ester), ethyl hexanoate, ethyl heptanoate, n-butyl propionate, n-propyl propionate, ethyl benzoate, di-n-propyl phthalate, benzoic acid ethoxyethyl ester, dipropyl carbonate, “Exxate 700” (a commercial C_7 alkyl acetate), “Exxate 800” (a commercial C_8 alkyl acetate), dibutyl phthalate, and tert-butyl acetate.

Lactone compatibilizers of the present invention comprise lactones represented by structures [A], [B], and [C]:

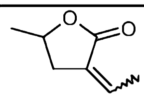
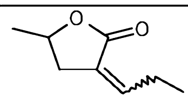
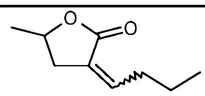
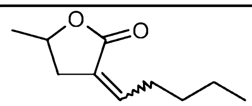
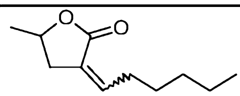
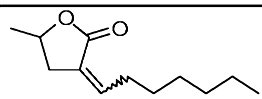
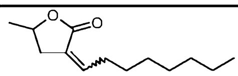
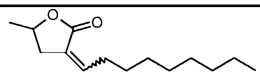


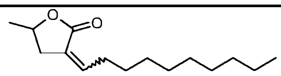
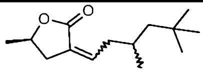
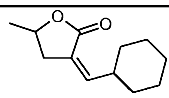
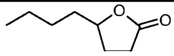
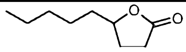
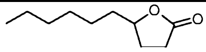
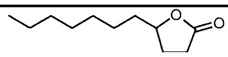
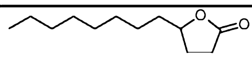
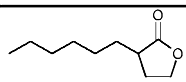
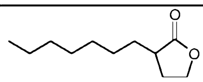
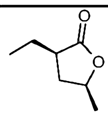
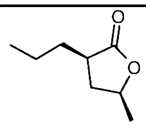
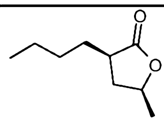
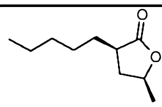
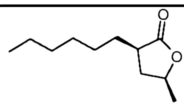
[A] [B] [C]

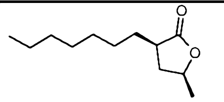
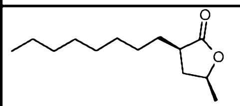
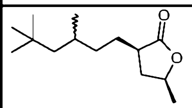
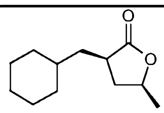
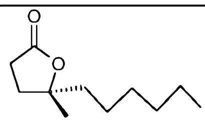
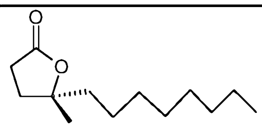
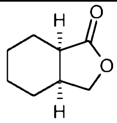
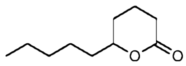
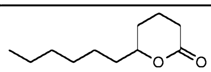
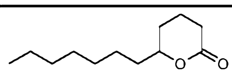
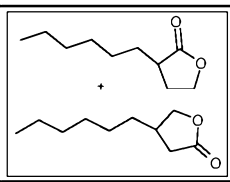
These lactones contain the functional group -CO_2- in a ring of six (A), or preferably five atoms (B), wherein for structures [A] and [B], R_1 through R_8 are independently selected from hydrogen or linear, branched, cyclic, bicyclic, saturated and unsaturated hydrocarbyl radicals. Each R_1 though R_8 may be connected forming a ring with another R_1 through R_8. The lactone may have an exocyclic alkylidene group as in structure [C], wherein R_1 through R_6 are independently selected from hydrogen or linear, branched, cyclic, bicyclic, saturated and unsaturated hydrocarbyl radicals. Each R_1 though R_6 may be connected forming a ring with another R_1 through R_6. The lactone compatibilizers have a molecular weight range of from about 80 to about 300 atomic mass units, preferred from about 80 to about 200 atomic mass units.

Representative lactone compatibilizers include but are not limited to the compounds listed in Table 8.

TABLE 8

Additive	Molecular Structure	Molecular Formula	Molecular Weight (amu)
(E,Z)-3-ethylidene-5-methyl-dihydro-furan-2-one		$C_7H_{10}O_2$	126
(E,Z)-3-propylidene-5-methyl-dihydro-furan-2-one		$C_8H_{12}O_2$	140
(E,Z)-3-butylidene-5-methyl-dihydro-furan-2-one		$C_9H_{14}O_2$	154
(E,Z)-3-pentylidene-5-methyl-dihydro-furan-2-one		$C_{10}H_{16}O_2$	168
(E,Z)-3-Hexylidene-5-methyl-dihydro-furan-2-one		$C_{11}H_{18}O_2$	182
(E,Z)-3-Heptylidene-5-methyl-dihydro-furan-2-one		$C_{12}H_{20}O_2$	196
(E,Z)-3-octylidene-5-methyl-dihydro-furan-2-one		$C_{13}H_{22}O_2$	210
(E,Z)-3-nonylidene-5-methyl-dihydro-furan-2-		$C_{14}H_{24}O_2$	224

one			
(E,Z)-3-decylidene-5-methyl-dihydro-furan-2-one		$C_{15}H_{26}O_2$	238
(E,Z)-3-(3,5,5-trimethylhexylidene)-5-methyl-dihydrofuran-2-one		$C_{14}H_{24}O_2$	224
(E,Z)-3-cyclohexylmethylidene-5-methyl-dihydrofuran-2-one		$C_{12}H_{18}O_2$	194
gamma-octalactone		$C_8H_{14}O_2$	142
gamma-nonalactone		$C_9H_{16}O_2$	156
gamma-decalactone		$C_{10}H_{18}O_2$	170
gamma-undecalactone		$C_{11}H_{20}O_2$	184
gamma-dodecalactone		$C_{12}H_{22}O_2$	198
3-hexyldihydro-furan-2-one		$C_{10}H_{18}O_2$	170
3-heptyldihydro-furan-2-one		$C_{11}H_{20}O_2$	184
cis-3-ethyl-5-methyl-dihydro-furan-2-one		$C_7H_{12}O_2$	128
cis-(3-propyl-5-methyl)-dihydro-furan-2-one		$C_8H_{14}O_2$	142
cis-(3-butyl-5-methyl)-dihydro-furan-2-one		$C_9H_{16}O_2$	156
cis-(3-pentyl-5-methyl)-dihydro-furan-2-one		$C_{10}H_{18}O_2$	170
cis-3-hexyl-5-methyl-dihydro-furan-2-one		$C_{11}H_{20}O_2$	184

cis-3-heptyl-5-methyl-dihydro-furan-2-one		$C_{12}H_{22}O_2$	198
cis-3-octyl-5-methyl-dihydro-furan-2-one		$C_{13}H_{24}O_2$	212
cis-3-(3,5,5-trimethylhexyl)-5-methyl-dihydro-furan-2-one		$C_{14}H_{26}O_2$	226
cis-3-cyclohexylmethyl-5-methyl-dihydro-furan-2-one		$C_{12}H_{20}O_2$	196
5-methyl-5-hexyl-dihydro-furan-2-one		$C_{11}H_{20}O_2$	184
5-methyl-5-octyl-dihydro-furan-2-one		$C_{13}H_{24}O_2$	212
Hexahydro-isobenzofuran-1-one		$C_8H_{12}O_2$	140
delta-decalactone		$C_{10}H_{18}O_2$	170
delta-undecalactone		$C_{11}H_{20}O_2$	184
delta-dodecalactone		$C_{12}H_{22}O_2$	198
mixture of 4-hexyl-dihydrofuran-2-one and 3-hexyl-dihydro-furan-2-one		$C_{10}H_{18}O_2$	170

Lactone compatibilizers generally have a kinematic viscosity of less than about 7 centistokes at 40°C. For instance, gamma-undecalactone has kinematic viscosity of 5.4 centistokes and cis-(3-hexyl-5-methyl)dihydrofuran-2-one has viscosity of 4.5 centistokes both at 40°C. Lactone compatibilizers may be available commercially or prepared by methods as described in U. S. patent application 10/910,495 filed August 3, 2004, incorporated herein by reference.

Aryl ether compatibilizers of the present invention further comprise aryl ethers represented by the formula R^1OR^2, wherein: R^1 is selected from aryl hydrocarbon radicals having from 6 to 12 carbon atoms; R^2 is selected from aliphatic hydrocarbon radicals having from 1 to 4 carbon atoms; and wherein said aryl ethers have a molecular weight of from about 100 to about 150 atomic mass units. Representative R^1 aryl radicals in the general formula R^1OR^2 include phenyl, biphenyl, cumenyl, mesityl, tolyl, xylyl, naphthyl and pyridyl. Representative R^2 aliphatic hydrocarbon radicals in the general formula R^1OR^2 include methyl, ethyl, propyl, isopropyl, butyl, isobutyl, *sec*-butyl and *tert*-butyl. Representative aromatic ether compatibilizers include but are not limited to: methyl phenyl ether (anisole), 1,3-dimethyoxybenzene, ethyl phenyl ether and butyl phenyl ether.

Fluoroether compatibilizers of the present invention comprise those represented by the general formula $R^1OCF_2CF_2H$, wherein R^1 is selected from aliphatic, alicyclic, and aromatic hydrocarbon radicals having from about 5 to about 15 carbon atoms, preferably primary, linear, saturated, alkyl radicals. Representative fluoroether compatibilizers include but are not limited to: $C_8H_{17}OCF_2CF_2H$ and $C_6H_{13}OCF_2CF_2H$. It should be noted that if the refrigerant is a fluoroether, then the compatibilizer may not be the same fluoroether.

Fluoroether compatibilizers may further comprise ethers derived from fluoroolefins and polyols. The fluoroolefins may be of the type CF_2=CXY, wherein X is hydrogen, chlorine or fluorine, and Y is chlorine, fluorine, CF_3 or OR_f, wherein R_f is CF_3, C_2F_5, or C_3F_7. Representative fluoroolefins are tetrafluoroethylene, chlorotrifluoroethylene, hexafluoropropylene, and perfluoromethylvinyl ether. The polyols may be linear or branched. Linear polyols may be of the type $HOCH_2(CHOH)_x(CRR')_yCH_2OH$, wherein R and R' are hydrogen, or CH_3, or C_2H_5 and wherein x is an integer from 0-4, and y is an integer from 0-4. Branched polyols may be of the type $C(OH)_t(R)_u(CH_2OH)_v[(CH_2)_mCH_2OH]_w$, wherein R may be hydrogen, CH_3 or C_2H_5, m may be an integer from 0 to 3, t and u may be 0 or 1, v and w are integers from 0 to 4, and also wherein t + u + v + w = 4. Representative polyols are trimethylol propane, pentaerythritol, butanediol, and ethylene glycol.

1,1,1-Trifluoroalkane compatibilizers of the present invention comprise 1,1,1-trifluoroalkanes represented by the general formula CF_3R^1, wherein R^1 is selected from aliphatic and alicyclic hydrocarbon radicals having from about 5 to about 15 carbon atoms, preferably primary, linear, saturated, alkyl radicals. Representative 1,1,1-trifluoroalkane compatibilizers include but are not limited to: 1,1,1-trifluorohexane and 1,1,1-trifluorododecane.

By effective amount of compatibilizer is meant that amount of compatibilizer that leads to efficient solubilizing of the lubricant in the composition and thus provides adequate oil return to optimize operation of the refrigeration, air-conditioning or heat pump apparatus.

The compositions of the present invention will typically contain from about 0.1 to about 40 weight percent, preferably from about 0.2 to about 20 weight percent, and most preferably from about 0.3 to about 10 weight percent compatibilizer in the compositions of the present invention.

The present invention further relates to a method of solubilizing a refrigerant or heat transfer fluid composition comprising the compositions of the present invention in a refrigeration lubricant selected from the group consisting of mineral oils, alkylbenzenes, synthetic paraffins, synthetic napthenes, and poly(alpha)olefins, wherein said method comprises contacting said lubricant with said composition in the presence of an effective amount of a compatibilizer, wherein said compatibilizer is selected from the group consisting of polyoxyalkylene glycol ethers, amides, nitriles, ketones, chlorocarbons, esters, lactones, aryl ethers, fluoroethers and 1,1,1-trifluoroalkanes.

The present invention further relates to a method for improving oil-return to the compressor in a compression refrigeration, air-conditioning or heat pump apparatus, said method comprising using a composition comprising compatibilizer in said apparatus.

The compositions of the present invention may further comprise an ultra-violet (UV) dye and optionally a solubilizing agent. The UV dye is a useful component for detecting leaks of the composition by permitting one to observe the fluorescence of the dye in the composition at a leak point or in the vicinity of refrigeration, air-conditioning, or heat pump apparatus. One may observe the fluoroscence of the dye under an ultra-violet light. Solubilizing agents may be needed due to poor solubility of such UV dyes in some compositions.

2012200235 16 Jan 2012

By "ultra-violet" dye is meant a UV fluorescent composition that absorbs light in the ultra-violet or "near" ultra-violet region of the electromagnetic spectrum. The fluorescence produced by the UV fluorescent dye under illumination by a UV light that emits radiation with wavelength anywhere from 10 nanometer to 750 nanometer may be detected. Therefore, if a composition containing such a UV fluorescent dye is leaking from a given point in a refrigeration, air-conditioning, or heat pump apparatus, the fluorescence can be detected at the leak point. Such UV fluorescent dyes include but are not limited to naphthalimides, perylenes, coumarins, anthracenes, phenanthracenes, xanthenes, thioxanthenes, naphthoxanthenes, fluoresceins, and derivatives or combinations thereof.

Solubilizing agents of the present invention comprise at least one compound selected from the group consisting of hydrocarbons, hydrocarbon ethers, polyoxyalkylene glycol ethers, amides, nitriles, ketones, chlorocarbons, esters, lactones, aryl ethers, fluoroethers and 1,1,1-trifluoroalkanes. The polyoxyalkylene glycol ethers, amides, nitriles, ketones, chlorocarbons, esters, lactones, aryl ethers, fluoroethers and 1,1,1-trifluoroalkanes solubilizing agents have been defined previously herein as being compatibilizers for use with conventional refrigeration lubricants.

Hydrocarbon solubilizing agents of the present invention comprise hydrocarbons including straight chained, branched chain or cyclic alkanes or alkenes containing 5 or fewer carbon atoms and only hydrogen with no other functional groups. Representative hydrocarbon solubilizing agents comprise propane, propylene, cyclopropane, n-butane, isobutane, 2-methylbutane and n-pentane. It should be noted that if the composition contains a hydrocarbon, then the solubilizing agent may not be the same hydrocarbon.

Hydrocarbon ether solubilizing agents of the present invention comprise ethers containing only carbon, hydrogen and oxygen, such as dimethyl ether (DME).

Solubilizing agents of the present invention may be present as a single compound, or may be present as a mixture of more than one solubilizing agent. Mixtures of solubilizing agents may contain two solubilizing agents from the same class of compounds, say two lactones, or two solubilizing agents from two different classes, such as a lactone and a polyoxyalkylene glycol ether.

In the present compositions comprising refrigerant and UV fluorescent dye, or comprising heat transfer fluid and UV fluorescent dye, from about 0.001 weight percent to about 1.0 weight percent of the composition is UV dye, preferably from about 0.005 weight percent to about 0.5 weight percent, and most preferably from 0.01 weight percent to about 0.25 weight percent.

Solubilizing agents such as ketones may have an objectionable odor, which can be masked by addition of an odor masking agent or fragrance. Typical examples of odor masking agents or fragrances may include Evergreen, Fresh Lemon, Cherry, Cinnamon, Peppermint, Floral or Orange Peel all commercially available, as well as d-limonene and pinene. Such odor masking agents may be used at concentrations of from about 0.001% to as much as about 15% by weight based on the combined weight of odor masking agent and solubilizing agent.

Solubility of these UV fluorescent dyes in the compositions of the present invention may be poor. Therefore, methods for introducing these dyes into the refrigeration, air-conditioning, or heat pump apparatus have been awkward, costly and time consuming. US patent no. RE 36,951 describes a method, which utilizes a dye powder, solid pellet or slurry of dye that may be inserted into a component of the refrigeration, air-conditioning, or heat pump apparatus. As refrigerant and lubricant are circulated through the apparatus, the dye is dissolved or dispersed and carried throughout the apparatus. Numerous other methods for introducing dye into a refrigeration or air conditioning apparatus are described in the literature.

Ideally, the UV fluorescent dye could be dissolved in the refrigerant itself thereby not requiring any specialized method for introduction to the refrigeration, air conditioning apparatus, or heat pump. The present invention relates to compositions including UV fluorescent dye, which may be introduced into the system as a solution in the refrigerant. The inventive compositions will allow the storage and transport of dye-containing compositions even at low temperatures while maintaining the dye in solution.

In the present compositions comprising refrigerant, UV fluorescent dye and solubilizing agent, or comprising heat transfer fluid and UV fluorescent dye and solubilizing agent, from about 1 to about 50 weight percent, preferably from about 2 to about 25 weight percent, and most preferably from about 5 to about 15 weight percent of the combined composition is solubilizing agent. In the compositions of the present invention the UV fluorescent dye is present in a concentration from about 0.001 weight percent to about 1.0 weight percent, preferably from 0.005 weight percent to about 0.5 weight percent, and most preferably from 0.01 weight percent to about 0.25 weight percent.

The present invention further relates to a method of using the compositions further comprising ultraviolet fluorescent dye, and optionally, solubilizing agent, in refrigeration, air-conditioning, or heat pump apparatus. The method comprises introducing the composition into the refrigeration, air-conditioning, or heat pump apparatus. This may be done by dissolving the UV fluorescent dye in the composition in the presence of a solubilizing agent and introducing the combination into the apparatus. Alternatively, this may be done by combining solubilizing agent and UV fluorescent dye and introducing said combination into refrigeration or air-conditioning apparatus containing refrigerant and/or heat transfer fluid. The resulting composition may be used in the refrigeration, air-conditioning, or heat pump apparatus.

The present invention further relates to a method of using the compositions comprising ultraviolet fluorescent dye to detect leaks. The presence of the dye in the compositions allows for detection of leaking refrigerant in a refrigeration, air-conditioning, or heat pump apparatus. Leak detection helps to address, resolve or prevent inefficient operation of the apparatus or system or equipment failure. Leak detection also helps one contain chemicals used in the operation of the apparatus.

The method comprises providing the composition comprising refrigerant, ultra-violet fluorescent dye, as described herein, and optionally, a solubilizing agent as described herein, to refrigeration, air-conditioning, or heat pump apparatus and employing a suitable means for detecting the UV fluorescent dye-containing refrigerant. Suitable means for detecting the dye include, but are not limited to, ultra-violet lamps, often referred to as a “black light” or “blue light”. Such ultra-violet lamps are commercially available from numerous sources specifically designed for this purpose. Once the ultra-violet fluorescent dye containing composition has been introduced to the refrigeration, air-conditioning, or heat pump apparatus and has been allowed to circulate throughout the system, a leak can be found by shining said ultra-violet lamp on the apparatus and observing the fluorescence of the dye in the vicinity of any leak point.

The present invention further relates to a method for replacing a high GWP refrigerant in a refrigeration, air-conditioning, or heat pump apparatus, wherein said high GWP refrigerant is selected from the group consisting of R134a, R22, R245fa, R114, R236fa, R124, R410A, R407C, R417A, R422A, R507A, and R404A,, said method comprising providing a composition of the present invention to said refrigeration, air-conditioning, or heat pump apparatus that uses, used or is designed to use said high GWP refrigerant.

Vapor-compression refrigeration, air-conditioning, or heat pump systems include an evaporator, a compressor, a condenser, and an expansion device. A vapor-compression cycle re-uses refrigerant in multiple steps producing a cooling effect in one step and a heating effect in a different step. The cycle can be described simply as follows. Liquid refrigerant enters an evaporator through an expansion device, and the liquid refrigerant boils in the evaporator at a low temperature to form a gas and produce cooling. The low-pressure gas enters a compressor where the gas is compressed to raise its pressure and temperature. The higher-pressure (compressed) gaseous refrigerant then enters the condenser in which the refrigerant condenses and discharges its heat to the environment. The refrigerant returns to the expansion device through which the liquid expands from the higher-pressure level in the condenser to the low-pressure level in the evaporator, thus repeating the cycle.

As used herein, mobile refrigeration apparatus or mobile air-conditioning apparatus refers to any refrigeration or air-conditioning apparatus incorporated into a transportation unit for the road, rail, sea or air. In addition, apparatus, which are meant to provide refrigeration or air-conditioning for a system independent of any moving carrier, known as “intermodal” systems, are included in the present invention. Such intermodal systems include “containers” (combined sea/land transport) as well as “swap bodies” (combined road and rail transport). The present invention is particularly useful for road transport refrigerating or air-conditioning apparatus, such as automobile air-conditioning apparatus or refrigerated road transport equipment.

The present invention further relates to a process for producing cooling comprising evaporating the compositions of the present invention in the vicinity of a body to be cooled, and thereafter condensing said compositions.

The present invention further relates to a process for producing heat comprising condensing the compositions of the present invention in the vicinity of a body to be heated, and thereafter evaporating said compositions.

The present invention further relates to a refrigeration, air-conditioning, or heat pump apparatus containing a composition of the present invention wherein said composition at least one fluoroolefin.

The present invention further relates to a mobile air-conditioning apparatus containing a composition of the present invention wherein said composition comprises at least one fluoroolefin.

The present invention further relates to a method for early detection of a refrigerant leak in a refrigeration, air-conditioning or heat pump apparatus said method comprising using a non-azeotropic composition in said apparatus, and monitoring for a reduction in cooling performance. The non-azeotropic compositions will fractionate upon leakage from a refrigeration, air-conditioning or heat pump apparatus and the lower boiling (higher vapor pressure) component will leak out of the apparatus first. When this occurs, if the lower boiling component in that composition provides the majority of the refrigeration capacity, there will be a marked reduction in the capacity and thus performance of the apparatus. In an automobile air-conditioning system, as an example, the passengers in the automobile will detect a reduction in the cooling capability of the system. This reduction in cooling capability can be interpreted to mean that refrigerant is being leaked and that the system requires repair.

The present invention further relates to a method of using the compositions of the present invention as a heat transfer fluid composition, said process comprising transporting said composition from a heat source to a heat sink.

Heat transfer fluids are utilized to transfer, move or remove heat from one space, location, object or body to a different space, location, object or body by radiation, conduction, or convection. A heat transfer fluid may function as a secondary coolant by providing means of transfer for cooling (or heating) from a remote refrigeration (or heating) system. In some systems, the heat transfer fluid may remain in a constant state throughout the transfer process (i.e., not evaporate or condense). Alternatively, evaporative cooling processes may utilize heat transfer fluids as well.

A heat source may be defined as any space, location, object or body from which it is desirable to transfer, move or remove heat. Examples of heat sources may be spaces (open or enclosed) requiring refrigeration or cooling, such as refrigerator or freezer cases in a supermarket, building spaces requiring air-conditioning, or the passenger compartment of an automobile requiring air-conditioning. A heat sink may be defined as any space, location, object or body capable of absorbing heat. A vapor compression refrigeration system is one example of such a heat sink.

In another embodiment, the present invention relates to blowing agent compositions comprising the fluoroolefin-containing compositions as described herein for use in preparing foams. In other embodiments the invention provides foamable compositions, and preferably polyurethane and polyisocyanate foam compositions, and method of preparing foams. In such foam embodiments, one or more of the present fluoroolefin-containing compositions are included as a blowing agent in foamable compositions, which composition preferably includes one or more additional components capable of reacting and foaming under the proper conditions to form a foam or cellular structure. Any of the methods well known in the art, such as those described in "Polyurethanes Chemistry and Technology," Volumes I and II, Saunders and Frisch, 1962, John Wiley and Sons, New York, N.Y., which is incorporated herein by reference, may be used or adapted for use in accordance with the foam embodiments of the present invention.

The present invention further relates to a method of forming a foam comprising: (a) adding to a foamable composition a fluoroolefin-containing composition of the present invention; and (b) reacting the foamable composition under conditions effective to form a foam.

Another embodiment of the present invention relates to the use of the fluoroolefin-containing compositions as described herein for use as propellants in sprayable compositions. Additionally, the present invention relates to a sprayable composition comprising the fluoroolefin-containing compositions as described herein. The active ingredient to be sprayed together with inert ingredients, solvents and other materials may also be present in a sprayable composition. Preferably, the sprayable composition is an aerosol. Suitable active materials to be sprayed include, without limitations, cosmetic materials, such as deodorants, perfumes, hair sprays, cleaners, and polishing agents as well as medicinal materials such as anti-asthma and anti-halitosis medications.

The present invention further relates to a process for producing aerosol products comprising the step of adding a fluoroolefin-containing composition as described herein to active ingredients in an aerosol container, wherein said composition functions as a propellant.

A further aspect provides methods of suppressing a flame, said methods comprising contacting a flame with a fluid comprising a fluoroolefin-containing composition of the present disclosure. Any suitable methods for contacting the flame with the present composition may be used. For example, a fluoroolefin-containing composition of the present disclosure may be sprayed, poured, and the like onto the flame, or at least a portion of the flame may be immersed in the flame suppression composition. In light of the teachings herein, those of skill in the art will be readily able to adapt a variety of conventional apparatus and methods of flame suppression for use in the present disclosure.

A further embodiment provides methods of extinguishing or suppressing a fire in a total-flood application comprising providing an agent comprising a fluoroolefin-containing composition of the present disclosure; disposing the agent in a pressurized discharge system; and discharging the agent into an area to extinguish or suppress fires in that area. Another embodiment provides methods of inerting an area to prevent a fire or explosion comprising providing an agent comprising a fluoroolefin-containing composition of the present disclosure; disposing the agent in a pressurized discharge system; and discharging the agent into the area to prevent a fire or explosion from occurring.

The term “extinguishment” is usually used to denote complete elimination of a fire; whereas, “suppression” is often used to denote reduction, but not necessarily total elimination, of a fire or explosion. As used herein, terms “extinguishment” and “suppression” will be used interchangeably. There are four general types of halocarbon fire and explosion protection applications. (1) In total-flood fire extinguishment and/or suppression applications, the agent is discharged into a space to achieve a concentration sufficient to extinguish or suppress an existing fire. Total flooding use includes protection of enclosed, potentially occupied spaces such, as computer rooms as well as specialized, often unoccupied spaces such as aircraft engine nacelles and engine compartments in vehicles. (2) In streaming applications, the agent is applied directly onto a fire or into the region of a fire. This is usually accomplished using manually operated wheeled or portable units. A second method, included as a streaming application, uses a “localized” system, which discharges agent toward a fire from one or more fixed nozzles. Localized systems may be activated either manually or automatically. (3) In explosion suppression, a fluoroolefin-containing composition of the present disclosure is discharged to suppress an explosion that has already been initiated. The term “suppression” is normally used in this application because the explosion is usually self-limiting. However, the use of this term does not necessarily imply that the explosion is not extinguished by the agent. In this application, a detector is usually used to detect an expanding fireball from an explosion, and the agent is discharged rapidly to suppress the explosion. Explosion suppression is used primarily, but not solely, in defense applications. (4) In inertion, a fluoroolefin-containing composition of the present disclosure is discharged into a space to prevent an explosion or a fire from being initiated. Often, a system similar or identical to that used for total-flood fire extinguishment or suppression is used. Usually, the presence of a dangerous condition (for example, dangerous concentrations of flammable or explosive gases) is detected, and the fluoroolefin-containing composition of the present disclosure is then discharged to prevent the explosion or fire from occurring until the condition can be remedied.

The extinguishing method can be carried out by introducing the composition into an enclosed area surrounding a fire. Any of the known methods of introduction can be utilized provided that appropriate quantities of the composition are metered into the enclosed area at appropriate intervals. For example, a composition can be introduced by streaming, e.g., using conventional portable (or fixed) fire extinguishing equipment; by misting; or by flooding, e.g., by releasing (using appropriate piping, valves, and controls) the composition into an enclosed area surrounding a fire. The composition can optionally be combined with an inert propellant, e.g., nitrogen, argon, decomposition products of glycidyl azide polymers or carbon dioxide, to increase the rate of discharge of the composition from the streaming or flooding equipment utilized.

Preferably, the extinguishing process involves introducing a fluoroolefin-containing composition of the present disclosure to a fire or flame in an amount sufficient to extinguish the fire or flame. One skilled in this field will recognize that the amount of flame suppressant needed to extinguish a particular fire will depend upon the nature and extent of the hazard. When the flame suppressant is to be introduced by flooding, cup burner test data is useful in determining the amount or concentration of flame suppressant required to extinguish a particular type and size of fire.

Laboratory tests useful for determining effective concentration ranges of fluoroolefin-containing compositions when used in conjunction with extinguishing or suppressing a fire in a total-flood application or fire inertion are described, for example, in U.S. Patent No. 5,759,430, which is hereby incorporated by reference.

EXAMPLES

EXAMPLE 1

Impact of vapor leakage

A vessel is charged with an initial composition at a temperature of either –25 °C or if specified, at 25 °C, and the initial vapor pressure of the composition is measured. The composition is allowed to leak from the vessel, while the temperature is held constant, until 50 weight percent of the initial composition is removed, at which time the vapor pressure of the composition remaining in the vessel is measured. Results are shown in Table 9.

TABLE 9

Composition wt%	Initial P (Psia)	Initial P (kPa)	After 50% Leak (Psia)	After 50% Leak (kPa)	Delta P (%)
HFC-1234yf/HFC-32					
7.4/92.6	49.2	339	49.2	339	0.0%
1/99	49.2	339	49.2	339	0.0%
20/80	49.0	338	48.8	337	0.3%
40/60	47.5	327	47.0	324	1.0%
57/43	44.9	309	40.5	280	9.6%
58/42	44.6	308	40.1	276	10.2%

HFC-1234yf/HFC-125					
10.9/89.1	40.8	281	40.8	281	0.0%
1/99	40.3	278	40.2	277	0.0%
20/80	40.5	279	40.3	278	0.4%
40/60	38.7	267	37.0	255	4.4%
50/50	37.4	258	34.0	235	9.0%
51/49	37.3	257	33.7	232	9.6%
52/48	37.1	256	33.3	229	10.3%
HFC-1234yf/HFC-134					
1/99	11.7	81	11.6	80	0.7%
10/90	12.8	88	12.2	84	4.5%
20/80	13.7	95	13.0	89	5.6%
40/60	15.2	105	14.6	101	4.1%
60/40	16.3	113	16.0	110	2.0%
80/20	17.2	119	17.1	118	0.6%
90/10	17.6	121	17.5	121	0.2%
99/1	17.8	123	17.8	123	0.0%
HFC-1234yf/HFC-134a					
70.4/29.6	18.4	127	18.4	127	0.0%
80/20	18.3	126	18.3	126	0.1%
90/10	18.2	125	18.1	125	0.1%
99/1	17.9	123	17.9	123	0.1%
40/60	17.9	123	17.8	123	0.7%
20/80	17.0	117	16.7	115	1.7%
10/90	16.4	113	16.1	111	1.5%
1/99	15.6	107	15.6	107	0.3%
HFC-1234yf/HFC-152a					
91.0/9.0	17.9	123	17.9	123	0.0%
99/1	17.9	123	17.8	123	0.1%
60/40	17.4	120	17.2	119	0.7%
40/60	16.6	115	16.4	113	1.6%
20/80	15.7	108	15.4	106	2.0%
10/90	15.1	104	14.9	103	1.5%
1/99	14.6	100	14.5	100	0.2%
HFC-1234yf/HFC-161					
1/99	25.3	174	25.3	174	0.0%
10/90	25.2	174	25.2	174	0.1%
20/80	24.9	172	24.8	171	0.8%
40/60	23.8	164	23.2	160	2.6%
60/40	22.0	152	21.3	147	3.2%
80/20	19.8	137	19.5	134	1.9%
90/10	18.8	129	18.6	128	0.9%
99/1	17.9	123	17.9	123	0.1%

HFC-1234yf/FC-143a					
17.3/82.7	39.5	272	39.5	272	0.0%
10/90	39.3	271	39.3	271	0.1%
1/99	38.7	267	38.6	266	0.1%
40/60	38.5	266	37.8	260	1.9%
60/40	36.3	250	32.8	226	9.5%
61/39	36.1	249	32.4	223	10.2%
HFC-1234yf/HFC-227ea					
84.6/15.4	18.0	124	18.0	124	0.0%
90/10	18.0	124	18.0	124	0.0%
99/1	17.9	123	17.9	123	0.0%
60/40	17.6	121	17.4	120	1.2%
40/60	16.7	115	15.8	109	5.4%
29/71	15.8	109	14.2	98	9.7%
28/72	15.7	108	14.1	97	10.2%
HFC-1234yf/HFC-236fa					
99/1	17.8	122	17.7	122	0.2%
90/10	17.0	117	16.6	115	2.4%
80/20	16.2	112	15.4	106	5.1%
70/30	15.3	106	14.0	97	8.5%
66/34	15.0	103	13.5	93	10.0%
HFC-1234yf/HFC-1225ye					
1/99	11.6	80	11.5	79	0.5%
10/90	12.6	87	12.2	84	3.2%
20/80	13.5	93	12.9	89	4.3%
40/60	15.0	103	14.4	99	3.7%
60/40	16.2	111	15.8	109	2.2%
80/20	17.1	118	16.9	117	0.9%
90/10	17.5	120	17.4	120	0.3%
99/1	17.8	123	17.8	123	0.0%
HFC-1234yf/trans-HFC-1234ze					
1/99	11.3	78	11.3	78	0.4%
10/90	12.2	84	11.8	81	3.3%
20/80	13.1	90	12.5	86	4.6%
40/60	14.6	101	14.0	96	4.3%
60/40	15.8	109	15.4	106	2.7%
80/20	16.9	117	16.7	115	1.1%
90/10	17.4	120	17.3	119	0.5%
99/1	17.8	123	17.8	123	0.1%
HFC-1234yf/HFC-1243zf					
1/99	13.1	90	13.0	90	0.2%
10/90	13.7	94	13.5	93	1.6%

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20/80	14.3	99	14.0	97	2.4%
40/60	15.5	107	15.1	104	2.2%
60/40	16.4	113	16.2	112	1.4%
80/20	17.2	119	17.1	118	0.5%
90/10	17.5	121	17.5	121	0.2%
99/1	17.8	123	17.8	123	0.0%
HFC-1234yf/propane					
51.5/48.5	33.5	231	33.5	231	0.0%
60/40	33.4	230	33.3	229	0.4%
80/20	31.8	220	29.0	200	8.9%
81/19	31.7	218	28.5	196	10.0%
40/60	33.3	230	33.1	228	0.6%
20/80	32.1	221	31.2	215	2.9%
10/90	31.0	214	30.2	208	2.6%
1/99	29.6	204	29.5	203	0.4%
HFC-1234yf/n-butane					
98.1/1.9	17.9	123	17.9	123	0.0%
99/1	17.9	123	17.9	123	0.0%
100/0	17.8	123	17.8	123	0.0%
80/20	16.9	116	16.1	111	4.4%
70/30	16.2	112	14.4	99	10.8%
71/29	16.3	112	14.6	101	9.9%
HFC-1234yf/isobutane					
88.1/11.9	19.0	131	19.0	131	0.0%
95/5	18.7	129	18.6	128	0.7%
99/1	18.1	125	18.0	124	0.6%
60/40	17.9	123	16.0	110	10.3%
61/39	17.9	123	16.2	112	9.4%
HFC-1234yf/DME					
53.5/46.5	13.1	90	13.1	90	0.0%
40/60	13.3	92	13.2	91	0.7%
20/80	14.1	97	13.9	96	1.3%
10/90	14.3	99	14.3	98	0.5%
1/99	14.5	100	14.5	100	0.0%
80/20	14.5	100	14.0	96	3.3%
90/10	15.8	109	15.3	105	3.5%
99/1	17.6	121	17.5	121	0.6%
HFC-1234yf/CF_3SCF_3					
1/99	12.1	83	12.0	83	0.2%
10/90	12.9	89	12.7	87	2.0%
20/80	13.8	95	13.4	92	2.8%
40/60	15.1	104	14.7	101	2.7%
60/40	16.2	112	15.9	110	1.9%

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80/20	17.1	118	16.9	117	0.9%
90/10	17.5	120	17.4	120	0.5%
99/1	17.8	123	17.8	123	0.0%
HFC-1234yf/CF_3I					
1/99	12.0	83	12.0	83	0.2%
10/90	12.9	89	12.7	87	1.7%
20/80	13.7	94	13.3	92	2.6%
40/60	15.1	104	14.7	101	2.7%
60/40	16.2	111	15.8	109	2.0%
80/20	17.1	118	16.9	116	1.1%
90/10	17.5	120	17.4	120	0.5%
99/1	17.8	123	17.8	123	0.1%
HFC-125/HFC-1234yf/isobutane (25 °C)					
85.1/11.5/3.4	201.3	1388	201.3	1388	0.0%
HFC-125/HFC-1234yf/n-butane (25 °C)					
67/32/1	194.4	1340	190.2	1311	2.2%
HFC-32/HFC-125/HFC-1234yf (25 °C)					
40/50/10	240.6	1659	239.3	1650	0.5%
23/25/52	212.6	1466	192.9	1330	9.3%
15/45/40	213.2	1470	201.3	1388	5.6%
10/60/30	213.0	1469	206.0	1420	3.3%
HFC-1225ye/trans-HFC-1234ze					
63.0/37.0	11.7	81	11.7	81	0.0%
80/20	11.6	80	11.6	80	0.0%
90/10	11.6	80	11.6	80	0.1%
99/1	11.5	79	11.5	79	0.0%
60/40	11.7	81	11.7	81	0.0%
40/60	11.6	80	11.6	80	0.1%
20/80	11.5	79	11.4	79	0.2%
10/90	11.3	78	11.3	78	0.1%
1/99	11.2	77	11.2	77	0.1%
HFC-1225ye/ HFC-1243zf					
40.0/60.0	13.6	94	13.6	94	0.0%
20/80	13.4	93	13.4	92	0.1%
10/90	13.2	91	13.2	91	0.2%
1/99	13.0	90	13.0	90	0.0%
60/40	13.4	92	13.4	92	0.4%
80/20	12.8	88	12.6	87	1.4%
90/10	12.3	85	12.1	83	1.5%
99/1	11.6	80	11.5	79	0.3%
HFC-1225ye/HFC-134					

52.2/47.8	12.8	88	12.8	88	0.0%
80/20	12.4	85	12.3	85	0.6%
90/10	12.0	83	11.9	82	0.8%
99/1	11.5	79	11.5	79	0.2%
40/60	12.7	88	12.7	87	0.2%
20/80	12.3	85	12.2	84	0.8%
10/90	12.0	83	11.9	82	0.9%
1/99	11.6	80	11.6	80	0.2%
HFC-1225ye/HFC-134a					
1/99	15.5	107	15.5	107	0.0%
10/90	15.2	105	15.2	105	0.3%
20/80	15.0	103	14.9	103	0.5%
40/60	14.4	99	14.2	98	1.0%
60/40	13.6	94	13.4	93	1.4%
80/20	12.7	88	12.5	86	1.6%
90/10	12.2	84	12.0	83	1.3%
99/1	11.5	80	11.5	79	0.2%
HFC-1225ye/HFC-152a					
7.3/92.7	14.5	100	14.5	100	0.0%
1/99	14.5	100	14.5	100	0.0%
40/60	14.2	98	14.2	98	0.4%
60/40	13.7	95	13.6	93	1.1%
80/20	12.9	89	12.7	87	1.5%
90/10	12.2	84	12.1	83	1.1%
99/1	11.5	80	11.5	79	0.1%
HFC-1225ye/HFC-161					
1/99	25.2	174	25.2	174	0.0%
10/90	24.9	172	24.8	171	0.6%
20/80	24.5	169	24.0	165	2.0%
40/60	22.9	158	21.4	148	6.5%
56/44	20.9	144	18.8	130	10.0%
99/1	11.7	81	11.6	80	1.0%
90/10	14.1	97	13.0	90	7.5%
84/16	15.5	107	14.0	96	9.9%
83/17	15.8	109	14.2	98	10.2%
HFC-1225ye/HFC-227ea					
1/99	10.0	69	10.0	69	0.0%
10/90	10.1	70	10.1	70	0.2%
20/80	10.3	71	10.3	71	0.2%
40/60	10.6	73	10.6	73	0.4%
60/40	10.9	75	10.9	75	0.4%
80/20	11.2	77	11.2	77	0.3%
90/10	11.3	78	11.3	78	0.1%
99/1	11.5	79	11.5	79	0.0%

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HFC-1225ye/HFC-236ea

99/1	11.4	79	11.4	79	0.0%
90/10	11.3	78	11.2	77	0.5%
80/20	11.0	75	10.7	74	2.0%
60/40	10.2	70	9.4	65	8.3%
57/43	10.1	69	9.1	63	9.9%
56/44	10.0	69	9.0	62	10.6%

HFC-1225ye/HFC-236fa

99/1	11.4	79	11.4	79	0.1%
90/10	11.1	77	11.0	76	1.1%
80/20	10.7	74	10.4	72	2.4%
60/40	9.8	68	9.2	63	6.6%
48/52	9.2	63	8.2	57	10.0%

HFC-1225ye/HFC-245fa

99/1	11.4	79	11.4	78	0.3%
90/10	10.9	75	10.6	73	2.5%
80/20	10.4	72	9.8	68	5.7%
70/30	9.9	68	8.9	61	9.9%
69/21	9.8	68	8.8	60	10.5%

HFC-1225ye/propane

29.7/70.3	30.4	209	30.4	209	0.0%
20/80	30.3	209	30.2	208	0.2%
10/90	30.0	207	29.9	206	0.4%
1/99	29.5	203	29.5	203	0.1%
60/40	29.5	203	28.5	197	3.3%
72/28	28.4	195	25.6	176	9.8%
73/27	28.2	195	25.2	174	10.8%

HFC-1225ye/n-butane

89.5/10.5	12.3	85	12.3	85	0.0%
99/1	11.7	81	11.6	80	0.9%
80/20	12.2	84	12.0	83	1.5%
65/35	11.7	80	10.5	72	9.9%
64/36	11.6	80	10.4	71	10.9%

HFC-1225ye/isobutane

79.3/20.7	13.9	96	13.9	96	0.0%
90/10	13.6	94	13.3	92	2.4%
99/1	11.9	82	11.6	80	2.8%
60/40	13.5	93	13.0	89	4.1%
50/50	13.1	91	11.9	82	9.6%
49/51	13.1	90	11.8	81	10.2%

HFC-1225ye/DME

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82.1/17.9	10.8	74	10.8	74	0.0%
90/10	10.9	75	10.9	75	0.3%
99/1	11.4	78	11.4	78	0.2%
60/40	11.5	79	11.2	77	2.4%
40/60	12.8	88	12.1	84	4.8%
20/80	13.9	96	13.5	93	3.0%
10/90	14.3	98	14.1	97	1.1%
1/99	14.5	100	14.4	100	0.1%
HFC-1225ye/CF_3I					
1/99	11.9	82	11.9	82	0.0%
10/90	11.9	82	11.8	82	0.1%
20/80	11.8	81	11.8	81	0.0%
40/60	11.7	80	11.7	80	0.0%
60/40	11.6	80	11.6	80	0.0%
80/20	11.5	79	11.5	79	0.0%
90/10	11.5	79	11.5	79	0.0%
99/1	11.5	79	11.5	79	0.0%
HFC-1225ye/CF_3SCF_3					
37.0/63.0	12.4	86	12.4	86	0.0%
20/80	12.3	85	12.3	85	0.1%
10/90	12.2	84	12.2	84	0.1%
1/99	12.0	83	12.0	83	0.1%
60/40	12.3	85	12.3	85	0.2%
80/20	12.0	83	11.9	82	0.4%
90/10	11.7	81	11.7	81	0.3%
99/1	11.5	79	11.5	79	0.1%
HFC-1225ye/HFC-134a/HFC-152a (25 °C)					
76/9/15	81.3	561	80.5	555	1.0%
HFC-1225ye/HFC-134a/HFC-161 (25 °C)					
86/10/4	82.1	566	80.2	553	2.3%
HFC-1225ye/HFC-134a/isobutane (25 °C)					
87/10/3	83.4	575	80.3	554	3.7%
HFC-1225ye/HFC-134a/DME (25 °C)					
87/10/3	77.2	532	76.0	524	1.6%
HFC-1225ye/HFC-152a/isobutane (25°C)					
85/13/2	81.2	560	79.3	547	2.3%
HFC-1225ye/HFC-152a/DME (25 °C)					
85/13/2	76.6	528	76.0	524	0.8%
HFC-1225ye/HFC-1234yf/HFC-134a (25 °C)					

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70/20/10	86.0	593	84.0	579	2.3%
20/70/10	98.2	677	97.5	672	0.7%
HFC-1225ye/HFC-1234yf/HFC-152a (25 °C)					
70/25/5	85.1	587	83.4	575	2.0%
25/70/5	95.4	658	94.9	654	0.5%
HFC-1225ye/HFC-1234yf/HFC-125 (25 °C)					
25/71/4	105.8	729	96.3	664	9.0%
75/21/4	89.5	617	83.0	572	7.3%
75/24/1	85.3	588	82.3	567	3.5%
25/74/1	98.0	676	95.1	656	3.0%
HFC-1225ye/HFC-1234yf/CF_3I (25 °C)					
40/40/20	87.5	603	86.0	593	1.7%
45/45/10	89.1	614	87.7	605	1.6%
HFC-1225ye/HFC-134a/HFC-152a/HFC-32 (25 °C)					
74/8/17/1	86.1	594	81.5	562	5.3%
HFC-125/HFC-1225ye/isobutane (25 °C)					
85.1/11.5/3.4	186.2	1284	179.2	1236	3.8%
HFC-32/HFC-125/HFC-1225ye (25 °C)					
30/40/30	212.7	1467	194.6	1342	8.5%
trans-HFC-1234ze/cis-HFC-1234ze					
99/1	11.1	77	11.1	76	0.4%
90/10	10.5	72	10.1	70	3.4%
80/20	9.8	68	9.1	63	7.1%
73/27	9.3	64	8.4	58	9.9%
72/28	9.3	64	8.3	57	10.3%
trans-HFC-1234ze/HFC-1243zf					
17.0/83.0	13.0	90	13.0	90	0.0%
10/90	13.0	90	13.0	90	0.0%
1/99	13.0	90	13.0	90	0.0%
40/60	12.9	89	12.9	89	0.1%
60/40	12.6	87	12.5	86	0.6%
80/20	12.1	83	12.0	82	0.8%
90/10	11.7	80	11.6	80	0.7%
99/1	11.2	77	11.2	77	0.1%
trans-HFC-1234ze/HFC-134					
45.7/54.3	12.5	86	12.5	86	0.0%
60/40	12.4	85	12.4	85	0.2%
80/20	12.0	83	11.9	82	0.7%
90/10	11.7	80	11.6	80	0.7%

99/1	11.2	77	11.2	77	0.1%
20/80	12.2	84	12.2	84	0.4%
10/90	11.9	82	11.9	82	0.6%
1/99	11.6	80	11.6	80	0.1%
trans-HFC-1234ze/HFC-134a					
9.5/90.5	15.5	107	15.5	107	0.0%
1/99	15.5	107	15.5	107	0.0%
40/60	15.1	104	15.0	103	0.9%
60/40	14.3	99	14.0	96	2.5%
80/20	13.1	90	12.6	87	4.0%
90/10	12.3	85	11.9	82	3.3%
99/1	11.3	78	11.3	78	0.5%
trans-HFC-1234ze/HFC-152a					
21.6/78.4	14.6	101	14.6	101	0.0%
10/90	14.6	101	14.6	101	0.0%
1/99	14.5	100	14.5	100	0.0%
40/60	14.5	100	14.5	100	0.1%
60/40	14.1	97	13.9	96	1.1%
80/20	13.2	91	12.8	88	2.5%
90/10	12.4	85	12.0	83	2.6%
99/1	11.3	78	11.3	78	0.4%
trans-HFC-1234ze/HFC-161					
1/99	25.2	174	25.2	174	0.0%
10/90	25.0	172	24.8	171	0.6%
20/80	24.5	169	24.0	165	2.1%
40/60	22.8	157	21.2	146	7.0%
52/48	21.3	147	19.2	132	9.9%
53/47	21.2	146	19.0	131	10.2%
99/1	11.5	79	11.3	78	1.2%
90/10	13.8	95	12.6	87	8.6%
88/12	14.3	99	12.9	89	9.5%
87/13	14.5	100	13.1	90	10.0%
trans-HFC-1234ze/HFC-227ea					
59.2/40.8	11.7	81	11.7	81	0.0%
40/60	11.6	80	11.5	79	0.3%
20/80	11.1	76	10.9	75	1.3%
10/90	10.6	73	10.5	72	1.3%
1/99	10.0	69	10.0	69	0.2%
80/20	11.6	80	11.5	80	0.2%
90/10	11.4	79	11.4	78	0.3%
99/1	11.2	77	11.2	77	0.0%
trans-HFC-1234ze/HFC-236ea					
99/1	11.2	77	11.2	77	0.0%

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90/10	11.0	76	11.0	76	0.4%
80/20	10.8	75	10.6	73	1.6%
60/40	10.2	70	9.5	66	6.6%
54/46	9.9	69	9.0	62	9.5%
53/47	9.9	68	8.9	61	10.1%
trans-HFC-1234ze/HFC-236fa					
99/1	11.2	77	11.2	77	0.1%
90/10	10.9	75	10.8	75	0.8%
80/20	10.6	73	10.4	71	2.0%
60/40	9.8	67	9.3	64	5.4%
44/56	9.0	62	8.1	56	9.7%
43/57	8.9	62	8.0	55	10.1%
trans-HFC-1234ze/HFC-245fa					
99/1	11.2	77	11.1	77	0.2%
90/10	10.7	74	10.5	73	2.0%
80/20	10.3	71	9.8	68	4.7%
70/30	9.8	68	9.0	62	8.2%
67/33	9.7	67	8.7	60	9.7%
66/34	9.6	66	8.7	60	10.2%
trans-HFC-1234ze/propane					
28.5/71.5	30.3	209	30.3	209	0.0%
10/90	30.0	206	29.9	206	0.3%
1/99	29.5	203	29.5	203	0.1%
40/60	30.2	208	30.1	207	0.4%
60/40	29.3	202	28.3	195	3.4%
71/29	28.4	196	25.7	177	9.3%
72/28	28.3	195	25.4	175	10.2%
trans-HFC-1234ze/n-butane					
88.6/11.4	11.9	82	11.9	82	0.0%
95/5	11.7	81	11.7	80	0.7%
99/1	11.4	78	11.3	78	0.6%
70/30	11.5	79	11.0	76	4.2%
62/38	11.2	77	10.2	70	9.3%
61/39	11.2	77	10.0	69	10.1%
trans-HFC-1234ze/isobutane					
77.9/22.1	12.9	89	12.9	89	0.0%
90/10	12.6	87	12.4	85	1.6%
99/1	11.4	79	11.3	78	1.1%
60/40	12.6	87	12.3	85	2.4%
39/61	11.7	81	10.6	73	9.8%
38/62	11.7	81	10.5	72	10.1%
trans-HFC-1234ze/DME					

84.1/15.9	10.8	74	10.8	74	0.0%
90/10	10.8	75	10.8	75	0.0%
99/1	11.1	77	11.1	77	0.0%
60/40	11.5	79	11.3	78	2.2%
40/60	12.7	88	12.2	84	4.4%
20/80	13.9	96	13.5	93	2.9%
10/90	14.3	98	14.1	97	1.0%
1/99	14.5	100	14.5	100	0.0%
trans-HFC-1234ze/CF_3SCF_3					
34.3/65.7	12.7	87	12.7	87	0.0%
20/80	12.6	87	12.6	87	0.2%
10/90	12.4	85	12.3	85	0.3%
1/99	12.0	83	12.0	83	0.1%
60/40	12.4	86	12.4	85	0.5%
80/20	12.0	82	11.8	81	1.1%
90/10	11.6	80	11.5	79	0.9%
99/1	11.2	77	11.2	77	0.2%
trans-HFC-1234ze/CF_3I					
1/99	11.9	82	11.9	82	0.0%
10/90	11.9	82	11.9	82	0.0%
20/80	11.8	81	11.8	81	0.0%
40/60	11.6	80	11.6	80	0.1%
60/40	11.4	79	11.4	79	0.1%
80/20	11.3	78	11.3	78	0.1%
90/10	11.3	78	11.2	77	0.1%
99/1	11.2	77	11.2	77	0.0%
HFC-32/HFC-125/trans-HFC-1234ze (25 °C)					
30/40/30	221.5	1527	209.4	1444	5.5%
30/50/20	227.5	1569	220.2	1518	3.2%
HFC-125/trans-HFC-1234ze/n-butane (25°C)					
66/32/2	180.4	1244	170.3	1174	5.6%
HFC-1243zf/HFC-134					
63.0/37.0	13.5	93	13.5	93	0.0%
80/20	13.4	93	13.4	92	0.1%
90/10	13.2	91	13.2	91	0.2%
99/1	13.0	90	13.0	90	0.0%
40/60	13.3	92	13.3	91	0.5%
20/80	12.7	88	12.6	87	1.3%
10/90	12.3	84	12.1	83	1.5%
1/99	11.6	80	11.6	80	0.3%
HFC-1243zf/HFC-134a					
25.1/74.9	15.9	110	15.9	110	0.0%

10/90	15.8	109	15.8	109	0.1%
1/99	15.5	107	15.5	107	0.1%
40/60	15.8	109	15.8	109	0.2%
60/40	15.3	106	15.1	104	1.2%
80/20	14.4	99	14.1	97	2.1%
90/10	13.8	95	13.5	93	1.7%
99/1	13.1	90	13.0	90	0.2%
HFC-1243zf/HFC-152a					
40.7/59.3	15.2	104	15.2	104	0.0%
20/80	15.0	103	15.0	103	0.2%
10/90	14.8	102	14.7	102	0.3%
1/99	14.5	100	14.5	100	0.1%
60/40	15.0	103	14.9	103	0.3%
80/20	14.4	99	14.2	98	1.1%
90/10	13.8	95	13.6	94	1.2%
99/1	13.1	90	13.1	90	0.2%
HFC-1243zf/HFC-161					
1/99	25.2	174	25.2	174	0.0%
10/90	24.9	172	24.8	171	0.3%
20/80	24.5	169	24.2	167	0.9%
40/60	23.3	160	22.6	156	2.9%
60/40	21.5	148	20.1	139	6.3%
78/22	18.8	130	16.9	117	10.0%
90/10	16.2	111	14.6	101	9.5%
99/1	13.4	92	13.1	90	1.7%
HFC-1243zf/HFC-227ea					
78.5/21.5	13.1	90	13.1	90	0.0%
90/10	13.1	90	13.1	90	0.0%
99/1	13.0	90	13.0	90	0.0%
60/40	13.0	90	13.0	89	0.2%
40/60	12.6	87	12.5	86	1.1%
20/80	11.8	81	11.5	79	2.7%
10/90	11.1	76	10.7	74	2.8%
1/99	10.1	69	10.0	69	0.6%
HFC-1243zf/HFC-236ea					
99/1	13.0	89	13.0	89	0.0%
90/10	12.8	88	12.7	87	0.5%
80/20	12.5	86	12.3	84	1.8%
60/40	11.7	81	11.0	76	6.6%
53/47	11.4	79	10.3	71	9.9%
52/48	11.4	78	10.2	70	10.5%
HFC-1243zf/HFC-236fa					
99/1	13.0	89	12.9	89	0.1%

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90/10	12.6	87	12.5	86	1.0%
80/20	12.2	84	11.9	82	2.5%
60/40	11.3	78	10.5	73	6.6%
49/51	10.6	73	9.6	66	9.9%
48/52	10.6	73	9.5	65	10.2%
HFC-1243zf/HFC-245fa					
99/1	12.9	89	12.9	89	0.2%
90/10	12.5	86	12.2	84	2.1%
80/20	12.0	83	11.4	79	4.6%
70/30	11.5	79	10.6	73	7.9%
66/34	11.3	78	10.2	70	9.6%
65/35	11.2	77	10.1	69	10.2%
HFC-1243zf/propane					
32.8/67.2	31.0	213	31.0	213	0.0%
10/90	30.3	209	30.1	207	0.7%
1/99	29.5	204	29.5	203	0.1%
60/40	30.1	208	29.2	201	3.2%
72/28	29.0	200	26.1	180	10.2%
71/29	29.2	201	26.5	182	9.3%
HFC-1243zf/n-butane					
90.3/9.7	13.5	93	13.5	93	0.0%
99/1	13.1	90	13.1	90	0.2%
62/38	12.6	87	11.4	79	9.4%
61/39	12.6	87	11.3	78	10.3%
HFC-1243zf/isobutane					
80.7/19.3	14.3	98	14.3	98	0.0%
90/10	14.1	97	14.0	96	0.9%
99/1	13.2	91	13.1	90	0.7%
60/40	13.8	95	13.4	92	3.2%
45/55	13.1	91	11.9	82	9.5%
44/56	13.1	90	11.8	81	10.1%
HFC-1243zf/DME					
72.7/27.3	12.0	83	12.0	83	0.0%
90/10	12.4	85	12.3	85	0.5%
99/1	12.9	89	12.9	89	0.1%
60/40	12.2	84	12.1	84	0.5%
40/60	13.0	90	12.7	88	2.2%
20/80	14.0	96	13.7	95	2.0%
10/90	14.3	99	14.2	98	0.6%
1/99	14.5	100	14.5	100	0.0%
cis-HFC-1234ze/HFC-236ea (25 °C)					
20.9/79.1	30.3	209	30.3	209	0.0%

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10/90	30.2	208	30.2	208	0.0%
1/99	29.9	206	29.9	206	0.0%
40/60	30.0	207	30.0	207	0.2%
60/40	29.2	201	28.9	199	0.9%
80/20	27.8	191	27.4	189	1.4%
90/10	26.8	185	26.5	183	1.1%
99/1	25.9	178	25.8	178	0.2%

cis-HFC-1234ze/HFC-236fa (25 °C)

1/99	39.3	271	39.3	271	0.0%
10/90	38.6	266	38.4	265	0.3%
20/80	37.6	259	37.3	257	0.9%
40/60	35.4	244	34.5	238	2.5%
60/40	32.8	226	31.4	216	4.3%
78/22	29.6	204	28.2	195	4.8%
90/10	27.8	192	26.9	185	3.4%
99/1	26.0	179	25.8	178	0.5%

cis-HFC-1234ze/HFC-245fa (25 °C)

76.2/23.7	26.2	180	26.2	180	0.0%
90/10	26.0	179	26.0	179	0.0%
99/1	25.8	178	25.8	178	0.0%
60/40	26.0	179	25.9	179	0.2%
40/60	25.3	174	25.0	173	0.9%
20/80	23.9	164	23.5	162	1.7%
10/90	22.8	157	22.5	155	1.5%
1/99	21.6	149	21.5	149	0.2%

cis-HFC-1234ze/n-butane

51.4/48.6	6.1	42	6.1	42	0.0%
80/20	5.8	40	5.2	36	9.3%
81/19	5.8	40	5.2	36	10.4%
40/60	6.1	42	6.0	41	0.7%
20/80	5.8	40	5.6	39	3.3%
10/90	5.6	38	5.4	37	3.1%
1/99	5.3	36	5.2	36	0.6%

cis-HFC-1234ze/isobutane

26.2/73.8	8.7	60	8.7	60	0.0%
10/90	8.7	60	8.6	59	0.3%
1/99	8.5	59	8.5	59	0.0%
40/60	8.7	60	8.6	60	0.5%
60/40	8.4	58	8.0	55	4.3%
70/30	8.1	56	7.3	50	10.3%
69/31	8.2	56	7.4	51	9.4%

cis-HFC-1234ze/2-methylbutane (25 °C)

86.6/13.4	27.3	188	27.3	188	0.0%

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90/10	27.2	187	27.2	187	0.1%
99/1	26.0	180	25.9	179	0.5%
60/40	25.8	178	24.0	166	6.9%
55/45	25.3	174	22.8	157	10.0%
cis-HFC-1234ze/n-pentane (25 °C)					
92.9/9.1	26.2	181	26.2	181	0.0%
99/1	25.9	178	25.9	178	0.1%
80/20	25.6	177	25.2	174	1.8%
70/30	24.8	171	23.5	162	5.6%
64/36	24.3	167	22.0	152	9.2%
63/37	24.2	167	21.8	150	9.9%
HFC-1234ye/HFC-134 (25 °C)					
1/99	75.9	523	75.8	523	0.1%
10/90	73.8	509	73.0	503	1.1%
20/80	71.3	491	69.0	476	3.1%
38/62	66.0	455	59.6	411	9.7%
39/61	65.7	453	58.9	406	10.2%
HFC-1234ye/HFC-236ea (-25 °C)					
24.0/76.0	3.4	23	3.4	23	0.0%
10/90	3.3	23	3.3	23	0.3%
1/99	3.3	23	3.3	23	0.0%
40/60	3.3	23	3.3	23	0.0%
60/40	3.2	22	3.2	22	0.9%
80/20	3.1	21	3.0	21	1.6%
90/10	2.9	20	2.9	20	1.4%
99/1	2.8	19	2.8	19	0.0%
HFC-1234ye/HFC-236fa (25 °C)					
1/99	39.2	270	39.2	270	0.1%
10/90	37.7	260	37.3	257	1.1%
20/80	36.1	249	35.2	243	2.5%
40/60	32.8	226	31.0	213	5.7%
60/40	29.3	202	26.7	184	8.8%
78/22	25.4	175	23.1	159	9.1%
90/10	23.2	160	21.7	150	6.3%
99/1	21.0	145	20.8	144	0.8%
HFC-1234ye/HFC-245fa (25 °C)					
42.5/57.5	22.8	157	22.8	157	0.0%
20/80	22.5	155	22.4	155	0.3%
10/90	22.1	152	22.0	152	0.3%
1/99	21.5	148	21.5	148	0.0%
60/40	22.6	156	22.6	156	0.2%
80/20	22.0	152	21.9	151	0.6%
90/10	21.5	148	21.3	147	0.6%

99/1	20.8	144	20.8	143	0.1%

HFC-1234ye/cis-HFC-1234ze (25 °C)

1/99	25.7	177	25.7	177	0.0%
10/90	25.6	176	25.6	176	0.0%
20/80	25.3	175	25.3	174	0.1%
40/60	24.7	170	24.5	169	0.5%
60/40	23.7	163	23.5	162	1.0%
78/22	22.4	155	22.2	153	1.2%
90/10	21.7	149	21.5	148	0.9%
99/1	20.9	144	20.8	144	0.1%

HFC-1234ye/n-butane (25 °C)

41.2/58.8	38.0	262	38.0	262	0.0%
20/80	37.3	257	37.0	255	0.8%
10/90	36.4	251	36.1	249	0.9%
1/99	35.4	244	35.3	243	0.2%
60/40	37.4	258	36.9	254	1.4%
70/30	36.5	252	34.9	241	4.4%
78/22	35.3	243	31.8	219	9.9%
79/21	35.1	242	31.3	216	10.9%

HFC-1234ye/cyclopentane (25 °C)

99/1	20.7	143	20.7	143	0.0%
90/10	20.3	140	20.0	138	1.0%
80/20	19.5	134	18.7	129	4.1%
70/30	18.6	128	16.9	116	9.5%
69/31	18.5	128	16.6	115	10.3%

HFC-1234ye/isobutane (25 °C)

16.4/83.6	50.9	351	50.9	351	0.0%
10/90	50.9	351	50.9	351	0.0%
1/99	50.5	348	50.5	348	0.0%
40/60	50.1	345	49.6	342	1.0%
60/40	47.8	330	45.4	313	5.2%
68/32	46.4	320	42.0	289	9.5%
69/31	46.2	318	41.4	286	10.3%

HFC-1234ye/2-methylbutane (25 °C)

80.3/19.7	23.1	159	23.1	159	0.0%
90/10	22.8	157	22.6	156	1.1%
99/1	21.2	146	20.9	144	1.0%
60/40	22.5	155	21.7	149	3.6%
47/53	21.5	148	19.4	134	9.6%
46/54	21.4	148	19.2	133	10.1%

HFC-1234ye/n-pentane (25 °C)

87.7/12.3	21.8	150	21.8	150	0.0%

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95/5	21.5	149	21.4	148	0.5%
99/1	21.0	145	20.9	144	0.4%
60/40	20.5	141	18.9	131	7.7%
57/43	20.3	140	18.3	126	9.7%
56/44	20.2	139	18.1	125	10.4%

The difference in vapor pressure between the original composition and the composition remaining after 50 weight percent is removed is less then about 10 percent for compositions of the present invention. This indicates that the compositions of the present invention would be azeotropic or near-azeotropic.

EXAMPLE 2

Refrigeration Performance Data

Table 10 shows the performance of various refrigerant compositions of the present invention as compared to HFC-134a. In Table 10, Evap Pres is evaporator pressure, Cond Pres is condenser pressure, Comp Disch T is compressor discharge temperature, COP is energy efficiency, and CAP is capacity. The data are based on the following conditions.

Evaporator temperature	40.0°F (4.4°C)
Condenser temperature	130.0°F (54.4°C)
Subcool temperature	10.0°F (5.5°C)
Return gas temperature	60.0°F (15.6°C)
Compressor efficiency is	100%

Note that the superheat is included in cooling capacity calculations.

TABLE 10

Composition (wt%)	**Evap Pres (Psia)**	**Evap Pres (kPa)**	**Cond Pres (Psia)**	**Cond Pres (kPa)**	**Comp Disch T (F)**	**Comp Disch T (C)**	**Cap (Btu/ min)**	**Cap (kW)**	**COP**
HFC-134a	50.3	346	214	1476	156	68.9	213	3.73	4.41
HFC-1225ye/HFC-152a (85/15)	39.8	274	173	1193	151	66.1	173	3.03	4.45
HFC-1225ye/HFC-32 (95/5)	46.5	321	197	1358	151	66.1	200	3.50	4.53
HFC-1225ye/HFC-32 (97/3)	43.1	297	184	1269	149	65.0	186	3.26	4.50
HFC-1225ye/HFC-134a (90/10)	39.5	272	172	1186	147	63.9	169	2.96	4.40
HFC-1225ye/CO_2 (99/1)	43.2	298	179	1234	146	63.3	177	3.10	4.63

HFC-1225ye/HFC-134a/HFC-32 (88/9/3)	44.5	307	190	1310	150	65.6	191	3.35	4.49
HFC-1225ye/HFC-134a/HFC-152a (76/9/15)	41.0	283	178	1227	153	67.2	178	3.12	4.44
HFC-1225ye/HFC-134a/HFC-161 (86/10/4)	42.0	290	181	1248	150	65.6	179	3.13	4.42
HFC-1225ye/HFC-134a/propane (87/10/3)	47.0	324	195	1345	148	64.4	197	3.45	4.49
HFC-1225ye/HFC-134a/i-butane (87/10/3)	41.7	288	178	1227	146	63.3	175	3.06	4.39
HFC-1225ye/HFC-134a/DME (87/10/3)	38.7	267	169	1165	149	65.0	168	2.94	4.44
HFC-1225ye/HFC-134a/CO_2 (88.5/11/.5)	42.4	292	180	1241	147	63.9	182	3.18	4.51
HFC-1225ye/HFC-134/HFC-32 (88/9/3)	43.0	296	185	1276	150	65.6	187	3.27	4.51
HFC-1225ye/HFC-152a/HFC-32 (85/10/5)	46.7	322	198	1365	155	68.3	203	3.55	4.53
HFC-1225ye/HFC-152a/HFC-32 (81/15/4)	45.5	314	193	1331	155	68.3	198	3.47	4.52
HFC-1225ye/HFC-152a/HFC-32 (82/15/3)	44.1	304	188	1296	155	68.3	192	3.36	4.50
HFC-1225ye/HFC-152a/propane (85/13/2)	44.4	306	185	1276	151	66.1	190	3.33	4.52
HFC-1225ye/HFC-152a/i-butane (85/13/2)	40.9	282	176	1214	150	65.6	175	3.06	4.44
HFC-1225ye/HFC-152a/DME (85/13/2)	39.0	269	170	1172	152	66.7	171	3.00	4.46
HFC-1225ye/HFC-152a/CO_2 (84/15/1)	44.8	309	185	1276	151	66.1	195	3.42	4.64
HFC-1225ye/ HFC-152a/CO_2 (84/15.5/0.5)	42.3	292	179	1234	151	66.1	184	3.22	4.55
HFC-1234yf/HFC-32 (95/5)	58.6	404	230	1586	149	65.0	228	4.00	4.36
HFC-1234yf/HFC-134a (90/10)	52.7	363	210	1448	145	62.8	206	3.61	4.33
HFC-1234yf/HFC-152a (80/20)	53.5	369	213	1468	150	65.6	213	3.73	4.38
trans-HFC-1234ze/HFC-32 (95/5)	42.6	294	183	1262	153	67.2	186	3.26	4.51
trans-HFC-1234ze/HFC-134a (90/10)	38.1	263	166	1145	149	65.0	165	2.89	4.44
trans-HFC-1234ze/HFC-152a (80/20)	41.0	284	176	1214	154	67.8	177	3.10	4.48
HFC-1225ye/HFC-1234yf (51/49)	46.0	317	190	1310	145	62.8	186	3.26	4.35
HFC-1225ye/HFC-1234yf (60/40)	44.0	303	187	1289	146	63.3	179	3.13	4.30
HFC-1225ye/HFC-1234yf/HFC-134a (70/20/10)	43.0	296	183	1261	147	63.9	179	3.13	4.38
HFC-1225ye/HFC-1234yf/HFC-134a (20/70/10)	50.7	350	205	1412	145	62.8	200	3.50	4.34
HFC-1225ye/HFC-1234yf/HFC-32 (25/73/2)	53.0	365	212	1464	146	63.3	210	3.68	4.37

HFC-1225ye/HFC-1234yf/HFC-32 (75/23/2)	45.3	312	190	1312	148	64.4	189	3.31	4.43
HFC-1225ye/HFC-1234yf/HFC-152a (70/25/5)	42.8	295	181	1250	147	63.9	179	3.13	4.40
HFC-1225ye/HFC-1234yf/HFC-152a (25/70/5)	49.9	344	202	1392	146	63.3	199	3.49	4.35
HFC-1225ye/HFC-1234yf/HFC-125 (25/71/4)	51.6	356	207	1429	145	62.8	202	3.54	4.33
HFC-1225ye/HFC-1234yf/HFC-125 (75/21/4)	43.4	299	184	1268	146	63.3	180	3.15	4.38
HFC-1225ye/HFC-1234yf/HFC-125 (75/24/1)	42.4	292	180	1241	145	62.8	176	3.08	4.39
HFC-1225ye/HFC-1234yf/HFC-125 (25/74/1)	50.2	346	202	1395	144	62.2	198	3.47	4.33
HFC-1225ye/HFC-1234yf (25/75)	49.8	343	201	1383	144	62.2	196	3.43	4.34
HFC-1225ye/HFC-1234yf/CF_3I (40/40/20)	47.9	330	195.0	1344	147.5	64.2	192	3.36	4.34
HFC-1225ye/HFC-1234yf/CF_3I (45/45/10)	47.0	324	192.9	1330	146	63.3	189	3.31	4.35
HFC-1225ye/HFC-1234yf/HFC-32 (49/49/2)	49.5	341	202.5	1396	146.9	63.8	201	3.52	4.4
HFC-1225ye/HFC-134a/HFC-152a/HFC-32 (74/8/17/1)trans-HFC	42.5	293	183	1260	154	67.8	184.3	3.23	4.47

Several compositions have even higher energy efficiency (COP) than HFC-134a while maintaining lower discharge pressures and temperatures. Capacity for the present compositions is also similar to R134a indicating these could be replacement refrigerants for R134a in refrigeration and air-conditioning, and in mobile air-conditioning applications in particular. Those compositions containing hydrocarbon may also improve oil solubility with conventional mineral oil and alkyl benzene lubricants.

EXAMPLE 3

Refrigeration Performance Data

Table 11 shows the performance of various refrigerant compositions of the present invention as compared to R404A and R422A. In Table 11, Evap Pres is evaporator pressure, Cond Pres is condenser pressure, Comp Disch T is compressor discharge temperature, EER is energy efficiency, and CAP is capacity. The data are based on the following conditions.

Evaporator temperature -17.8°C
Condenser temperature 46.1°C

Subcool temperature	5.5°C
Return gas temperature	15.6°C
Compressor efficiency is	70%

Note that the superheat is included in cooling capacity calculations.

TABLE 11

Existing Refrigerant Product		Evap Press (kPa))	Cond P Press (kPa)	Compr Disch T (C)	CAP (kJ/m3)	EER
R22		267	1774	144	1697	4.99
R404A		330	2103	101.1	1769	4.64
R507A		342	2151	100.3	1801	4.61
R422A		324	2124	95.0	1699	4.54
Candidate Replacement	wt%					
HFC-125/HFC-1225ye/isobutane	85.1/11.5/3.4	330	2137	93.3	1699	4.50
HFC-125/trans-HFC-1234ze/isobutane	86.1/11.5/2.4	319	2096	94.4	1669	4.52
HFC-125/HFC-1234yf/isobutane	87.1/11.5/1.4	343	2186	93.3	1758	4.52
HFC-125/HFC-1225ye/n-butane	85.1/11.5/3.4	322	2106	93.5	1674	4.52
HFC-125/trans-HFC-1234ze/n-butane	86.1/11.5/2.4	314	2083	94.8	1653	4.53
HFC-125/HFC-1234yf/n-butane	87.1/11.5/1.4	340	2173	93.4	1748	4.53
HFC-32/HFC-125/HFC-1225ye	10/10/'80	173	1435	107	1159	4.97
HFC-32/HFC-125/HFC-1225ye	25/25/50	276	2041	120	1689	4.73
HFC-32/HFC-125/HFC-1225ye	25/40/35	314	2217	119	1840	4.66
HFC-32/HFC-125/HFC-1225ye	30/10/60	265	1990	125	1664	4.78
HFC-32/HFC-125/HFC-1225ye	30/15/55	276	2046	125	1710	4.76
HFC-32/HFC-125/HFC-1225ye	30/20/50	287	2102	124	1757	4.73
HFC-32/HFC-125/HFC-1225ye	30/30/40	311	2218	124	1855	4.68
HFC-32/HFC-125/HFC-1225ye	30/35/35	324	2271	123	1906	4.66
HFC-32/HFC-125/HFC-1225ye	35/15/50	296	2157	129	1820	4.72
HFC-32/HFC-125/HFC-1225ye	35/20/45	308	2212	129	1868	4.70
HFC-32/HFC-125/HFC-1225ye	35/30/35	332	2321	127	1968	4.66
HFC-32/HFC-125/HFC-1225ye	35/40/25	357	2424	126	2068	4.64
HFC-32/HFC-	50/30/20	390	2584	138	2277	4.54

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125/HFC-1225ye						
HFC-32/HFC-125/HFC-1225ye	40/30/30	353	2418	131	2077	4.66
HFC-32/HFC-125/HFC-1225ye	40/35/25	364	2465	131	2124	4.64
HFC-32/HFC-125/HFC-1225ye	45/30/25	372	2505	135	2180	4.66
HFC-32/HFC-125/HFC-152a/HFC-1225ye	10/20/10/60	190	1517	110	1255	4.97
HFC-32/HFC-125/HFC-152a/HFC-1225ye	15/25/10/50	221	1709	115	1422	4.90
HFC-32/HFC-125/HFC-152a/HFC-1225ye	20/20/15/45	229	1755	121	1485	4.90
HFC-32/HFC-125/HFC-152a/HFC-1225ye	30/20/50	272	1984	130	1706	4.80
HFC-32/HFC-125/HFC-152a/HFC-1225ye	40/10/50	299	2159	137	1860	1.00
HFC-32/HFC-125/HFC-152a/HFC-1225ye	30/30/40	286	2030	133	1774	4.80
HFC-32/HFC-125/HFC-152a/HFC-1225ye	30/60/10	314	2120	144	1911	4.75
HFC-32/HFC-125/HFC-152a/HFC-1225ye	40/20/40	315	2214	139	1936	4.73
HFC-32/HFC-125/HFC-152a/HFC-1225ye	30/50/20	309	2101	139	1885	4.78
HFC-32/HFC-125/HFC-152a/HFC-1225ye	40/40/20	346	2309	145	2079	4.71
HFC-32/HFC-125/HFC-152a/HFC-1225ye	45/45/10	373	2432	152	2217	4.67
HFC-32/HFC-125/HFC-152a/HFC-1225ye	45/10/45	319	2260	141	1964	4.71
HFC-32/HFC-125/HFC-152a/HFC-1225ye	50/10/40	338	2353	145	2065	4.68
HFC-32/HFC-125/HFC-152a/HFC-1225ye	50/20/30	356	2410	147	2150	4.68
HFC-32/HFC-125/HFC-152a/HFC-1225ye	25/5/70	230	1781	122	1495	4.90
HFC-32/HFC-125/HFC-152a/HFC-1225ye	60/30/10	409	2626	158	2434	4.66
HFC-32/HFC-125/HFC-152a/HFC-1225ye	50/25/25	364	2437	149	2192	4.68

HFC-32/HFC-125/HFC-152a/HFC-1225ye	50/20/30	356	2410	147	2156	4.68
HFC-32/HFC-125/HFC-152a/HFC-1225ye	25/50/25	284	1964	134	1754	4.85
HFC-32/HFC-125/HFC-152a/HFC-1225ye	45/30/25	353	2368	146	2124	4.71
HFC-32/CF_3I/HFC-1234yf	5/50/45	199	1377	107	1254	5.11
HFC-32/CF_3I/HFC-1234yf	5/30/65	197	1382	103	1241	5.11
HFC-32/CF_3I/HFC-1234yf	10/25/65	220	1542	107	1374	5.04
HFC-32/CF_3I/HFC-1234yf	20/10/70	255	1786	114	1577	4.95
HFC-32/CF_3I/HFC-1234yf	30/10/60	295	2020	123	1795	4.88
HFC-32/CF_3I/HFC-1234yf	30/20/50	305	2057	125	1843	4.85
HFC-32/CF_3I/HFC-1234yf	30/30/40	314	2091	128	1887	4.85
HFC-32/CF_3I/HFC-1234yf	20/40/40	275	1861	121	1679	4.92
HFC-32/CF_3I/HFC-1234yf	10/40/50	225	1558	111	1404	5.04
HFC-32/CF_3I/HFC-1234yf	50/20/30	378	2447	143	2238	4.73
HFC-32/CF_3I/HFC-1234yf	40/30/30	354	2305	137	2099	4.76
HFC-32/CF_3I/HFC-1234yf	40/40/20	360	2336	142	2136	4.74
HFC-32/CF_3I/HFC-1234yf	35/35/30	338	2217	135	2015	4.78
HFC-32/CF_3I/HFC-1234yf	35/30/35	334	2202	133	1996	4.80
HFC-32/CF_3I/HFC-1234yf	50/25/25	384	2468	145	2267	4.72
HFC-32/CF_3I/HFC-1225ye/HFC-1234yf	40/20/20/20	331	2246	136	1999	4.76
HFC-32/CF_3I/HFC-1225ye/HFC-1234yf	30/20/25/25	290	2029	127	1782	4.83
HFC-32/CF_3I/HFC-1225ye/HFC-1234yf	30/10/30/30	279	1987	125	1728	4.83
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	25/25/25/25	297	2089	118	1772	4.76
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	20/30/25/25	286	2025	113	1702	4.64
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	20/30/30/20	290	2033	113	1717	4.76
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	20/30/40/10	297	2048	112	1746	4.78
HFC-32/HFC-	30/30/20/20	328	2251	122	1925	4.71

125/HFC-1234yf/HFC-1225ye						
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	30/30/1/39	312	2217	123	1858	4.68
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	30/30/39/1	342	2275	120	1979	4.73
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	30/30/10/30	320	2235	123	1891	4.68
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	35/30/5/30	337	2330	127	1986	4.66
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	20/15/10/55	240	1818	115	1513	4.85
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	30/15/10/45	284	2066	124	1743	4.76
HFC-32/HFC-125/HFC-1234yf/HFC-1225ye	40/30/15/15	341	2364	132	2022	4.66
HFC-32/HFC-125/CF_3I/HFC-1234yf/HFC-1225ye	30/25/5/35/5	335	2240	121	1954	4.76
HFC-32/HFC-125/CF_3I/HFC-1234yf	30/25/5/40	338	2245	121	1966	4.76
HFC-32/HFC-125/HFC-1225ye/isobutane	25/35/35/5	323	2195	115	1837	4.64
HFC-32/HFC-125/HFC-1225ye/isobutane	25/38/35/2	318	2214	117	1837	4.64
HFC-32/HFC-125/HFC-1225ye/propane	25/38/35/2	330	2297	118	1892	4.59
HFC-32/CF_3I/HFC-1225ye/DME	50/20/25/5	321	2252	150	2010	4.76
HFC-32/HFC-125/HFC-1225ye/DME	35/30/30/5	293	2135	131	1823	4.76
HFC-32/HFC-125/HFC-1225ye/DME	35/33/30/2	320	2268	129	1925	4.68
HFC-32/HFC-125/HFC-1225ye/DME	35/35/28/2	324	2288	129	1943	4.68
HFC-32/HFC-125/HFC-1234yf	25/50/25	365	2376	115	2040	4.66
HFC-32/HFC-125/HFC-1234yf	30/30/40	343	2276	120	1982	4.73
HFC-32/HFC-125/HFC-1234yf	20/30/50	303	2059	112	1770	4.78
HFC-32/HFC-125/CF_3I/HFC-1234yf	25/25/10/40	323	2154	118	1884	4.78
HFC-32/HFC-125/CF_3I/HFC-	25/25/10/40	291	2088	121	1757	4.73

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1225ye						
HFC-32/HFC-125/CF_3I/HFC-1225ye	20/30/10/40	279	2017	117	1680	4.73
HFC-32/HFC-125/CF_3I/HFC-1225ye	20/35/5/40	285	2056	116	1699	4.71

Several compositions have energy efficiency (COP) comparable top R404A and R422A. Discharge temperatures are also lower than R404A and R507A. Capacity for the present compositions is also similar to R404A, R507A, and R422A indicating these could be replacement refrigerants for in refrigeration and air-conditioning. Those compositions containing hydrocarbon may also improve oil solubility with conventional mineral oil and alkyl benzene lubricants.

EXAMPLE 4

Refrigeration Performance Data

Table 12 shows the performance of various refrigerant compositions of the present invention as compared to HCFC-22, R410A, R407C, and R417A. In Table 12, Evap Pres is evaporator pressure, Cond Pres is condenser pressure, Comp Disch T is compressor discharge temperature, EER is energy efficiency, and CAP is capacity. The data are based on the following conditions.

Evaporator temperature	4.4°C
Condenser temperature	54.4°C
Subcool temperature	5.5°C
Return gas temperature	15.6°C
Compressor efficiency is	100%

Note that the superheat is included in cooling capacity calculations.

TABLE 12

Existing Refrigerant Product		Evap Press (kPa))	Cond Press (kPa)	Compr Disch T (C)	CAP (kJ/m3)	EER
R22		573	2149	88.6	3494	14.73
R410A		911	3343	89.1	4787	13.07
R407C		567	2309	80.0	3397	14.06
R417A		494	1979	67.8	2768	13.78
Candidate Replacement	wt%					

HFC-32/HFC-125/HFC-1225ye	30/40/30	732	2823	81.1	3937	13.20
HFC-32/HFC-125/HFC-1225ye	23/25/52	598	2429	78.0	3409	13.54
HFC-32/HFC-125/trans-HFC-1234ze	30/50/20	749	2865	81.7	3975	13.10
HFC-32/HFC-125/trans-HFC-1234ze	23/25/52	546	2252	78.9	3222	13.80
HFC-32/HFC-125/HFC-1234yf	40/50/10	868	3185	84.4	4496	13.06
HFC-32/HFC-125/HFC-1234yf	23/25/52	656	2517	76.7	3587	13.62
HFC-32/HFC-125/HFC-1234yf	15/45/40	669	2537	73.3	3494	13.28
HFC-32/HFC-125/HFC-1234yf	10/60/30	689	2586	71.3	3447	12.96
HFC-125/HFC-1225ye/n-butane	65/32/3	563	2213	66.1	2701	12.87
HFC-125/trans-HFC-1234ze/n-butane	66/32/2	532	2130	67.2	2794	13.08
HFC-125/HFC-1234yf/n-butane	67/32/1	623	2344	66.1	3043	12.85
HFC-125/HFC-1225ye/isobutane	65/32/3	574	2244	66.2	2874	12.79
HFC-125/trans-HFC-1234ze/isobutane	66/32/2	538	2146	67.4	2808	13.04
HFC-125/HFC-1234yf/isobutane	67/32/1	626	2352	66.3	3051	12.83

Compositions have energy efficiency (EER) comparable to R22, R407C, R417A, and R410A while maintaining low discharge temperatures. Capacity for the present compositions is also similar to R22, R407C and R417A indicating these could be replacement refrigerants for in refrigeration and air-conditioning. Those compositions containing hydrocarbon may also improve oil solubility with conventional mineral oil and alkyl benzene lubricant.

EXAMPLE 5

Refrigeration Performance Data

Table 12 shows the performance of various refrigerant compositions of the present invention as compared to HCFC-22 and R410A. In Table 12, Evap Pres is evaporator pressure, Cond Pres is condenser pressure, Comp Disch T is compressor discharge temperature, EER is energy efficiency, and CAP is capacity. The data are based on the following conditions.

Evaporator temperature	4°C
Condenser temperature	43°C
Subcool temperature	6°C
Return gas temperature	18°C
Compressor efficiency is	70%

Note that the superheat is included in cooling capacity calculations.

TABLE 13

Composition (wt%)	Evap Press (kPa)	Cond Press (kPa)	Compr Disch Temp (C)	CAP (kJ/m3)	EER
R22	565	1648	90.9	3808	9.97
R410A	900	2571	88.1	5488	9.27
HFC-32/HFC-1225ye (40/60)	630	1948	86.7	4242	9.56
HFC-32/HFC-1225ye (45/55)	666	2041	88.9	4445	9.49
HFC-32/HFC-1225ye (50/50)	701	2127	91.0	4640	9.45
HFC-32/HFC-1225ye/CF_3I (40/30/20)	711	2104	90.6	4605	9.56
HFC-32/HFC-1225ye/CF_3I (45/30/25)	737	2176	92.2	4765	9.45
HFC-32/HFC-1225ye/CF_3I (45/35/20)	724	2151	91.4	4702	9.45
HFC-32/HFC-134a/HFC-1225ye (40/30/30)	607	1880	87.8	4171	9.69
HFC-32/HFC-134a/HFC-1225ye (45/30/25)	637	1958	89.9	4347	9.66
HFC-32/HFC-134a/HFC-1225ye (45/35/20)	631	1944	90.2	4326	9.69
HFC-32/HFC-134a/HFC-1234yf/CF_3I (30/20/5/45)	611	1845	89.6	4107	9.66
HFC-32/HFC-134a/HFC-1234yf/CF_3I (25/20/10/45)	575	1745	86.5	3891	9.76
HFC-32/HFC-134a/HFC-1234yf/CF_3I (35/10/5/40)	646	1939	91.2	4308	9.62
HFC-32/HFC-134a/HFC-1225ye/HFC-1234yf (34/12/47/7)	587	1822	84	4001	9.69
HFC-32/HFC-134a/HFC-1225ye/HFC-1234yf (30/8/52/10)	561	1752	81.9	3841	9.73

HFC-32/HFC-134a/HFC-1225ye/HFC-1234yf (35/6/52/7)	597	1852	84.3	4051	9.66

Compositions have energy efficiency (EER) comparable to R22 and R410A while maintaining reasonable discharge temperatures. Capacity for the present compositions is also similar to R22 indicating these could be replacement refrigerants for in refrigeration and air-conditioning.

EXAMPLE 6

Flammability

Flammable compounds may be identified by testing under ASTM (American Society of Testing and Materials) E681-01, with an electronic ignition source. Such tests of flammability were conducted on HFC-1234yf, HFC-1225ye and a mixture of the present disclosure at 101 kPa (14.7 psia), 100 °C (212 °F), and 50 percent relative humidity, at various concentrations in air in order to determine the lower flammability limit (LFL) and upper flammability limit (UFL). The results are given in Table 13.

TABLE 14

Composition	LFL (vol % in air)	UFL (vol % in air)
HFC-1225ye (100 wt%)	Non-flammable	Non-flammable
HFC-1234yf (100 wt%)	5.0	14.5
HFC-1234yf/1225ye (50/50 wt%)	8.5	12.0
HFC-1234yf/1225ye (40/60 wt%)	Non-flammable	Non-flammable

The results indicate that while HFC-1234yf is flammable, addition of HFC-1225ye reduces the flammability. Therefore, compositions comprising about 1 weight percent to about 49 weight percent HFC-1234yf and about 99 weight percent to about 51 weight percent HFC-1225ye are preferred.

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The Claims defining the invention are as follows:

1. A composition comprising an azeotropic or near azeotropic composition selected from the group consisting of:

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-1234yf;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-1243zf;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-134;

about 1 weight percent to about 52 weight percent trans-HFC-1234ze and about 99 weight percent to about 48 weight percent HFC-161 and about 87 weight percent to about 99 weight percent trans-HFC-1234ze and about 13 weight percent to about 1 weight percent HFC-161;

about 54 weight percent to about 99 weight percent trans-HFC-1234ze and about 46 weight percent to about 1 weight percent HFC-236ea;

about 44 weight percent to about 99 weight percent trans-HFC-1234ze and about 56 weight percent to about 1 weight percent HFC-236fa;

about 67 weight percent to about 99 weight percent trans-HFC-1234ze and about 33 weight percent to about 1 weight percent HFC-245fa;

about 1 weight percent to about 71 weight percent trans-HFC-1234ze and about 99 weight percent to about 29 weight percent propane;

about 62 weight percent to about 99 weight percent trans-HFC-1234ze and about 38 weight percent to about 1 weight percent n-butane;

about 39 weight percent to about 99 weight percent trans-HFC-1234ze and about 61 weight percent to about 1 weight percent isobutane;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent dimethylether;

about 1 weight percent to about 99 weight percent trans-HFC-1234ze and about 99 weight percent to about 1 weight percent bis(trifluorometh y)sulfide;

about 80 weight percent to about 98 weight percent HFC-125, about 1 weight percent to about 19 weight percent trans-HFC-1234ze and about 1 weight percent to about 10 weight percent isobutane;

about 1 weight percent to about 98 weight percent HFC-32, about 1 weight percent to about 98 weight percent HFC-125, and about 1 weight percent to about 5 weight percent trans-HFC-1234ze;

about 80 weight percent to about 98 weight percent HFC-125, about 1 weight percent to about 19 weight percent trans-HFC-1234ze and about 1 weight percent to about 10 weight percent n-butane;

about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-1234ye;

about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-236ea;

about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-236fa;

about 1 weight percent to about 99 weight percent cis-HFC-1234ze and about 99 weight percent to about 1 weight percent HFC-245fa;

about 1 weight percent to about 80 weight percent cis-HFC-1234ze and about 99 weight percent to about 20 weight percent n-butane;

about 1 weight percent to about 69 weight percent cis-HFC-1234ze and about 99 weight percent to about 31 weight percent isobutane;

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about 60 weight percent to about 99 weight percent cis-HFC-1234ze and about 40 weight percent to about 1 weight percent 2-methylbutane;

about 63 weight percent to about 99 weight percent cis-HFC-1234ze and about 37 weight percent to about 1 weight percent n-pentane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 98 weight percent HFC-227ea;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 30 weight percent n-butane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 40 weight percent isobutane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-1243zf and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-134 and about 1 weight percent to about 98 weight percent HFC-152a;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-134 and about 1 weight percent to about 98 weight percent HFC-227ea;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-134 and about 1 weight percent to about 40 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent

HFC-152a and about 1 weight percent to about 50 weight percent n-butane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-152a and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 98 weight percent HFC-227ea and about 1 weight percent to about 40 weight percent n-butane;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 40 weight percent n-butane and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 60 weight percent isobutane and about 1 weight percent to about 98 weight percent dimethylether;

about 1 weight percent to about 98 weight percent trans-HFC-1234ze, about 1 weight percent to about 40 weight percent isobutane and about 1 weight percent to about 98 weight percent CF_3SCF_3;

9.5 weight percent trans-HFC-1234ze and 90.5 weight percent HFC-134a having a vapor pressure of about 15.5 psia (107 kPa) at a temperature of about -25 °C;

21.6 weight percent trans-HFC-1234ze and 78.4 weight percent HFC-152a having a vapor pressure of about 14.6 psia (101 kPa) at a temperature of about -25 °C; and

59.2 weight percent trans-HFC-1234ze and 40.8 weight percent HFC-227ea having a vapor pressure of about 11.7 psia (81 kPa) at a temperature of about -25 °C.

2. A composition of claim 1 comprising an azeotropic composition selected from the group consisting of:

17.0 weight percent trans-HFC-1234ze and 83.0 weight percent HFC-1243zf having a vapor pressure of about 13.0 psia (90 kPa) at a temperature of about -25 °C;

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45.7 weight percent trans-HFC-1234ze and 54.3 weight percent HFC-134 having a vapor pressure of about 12.5 psia (86 kPa) at a temperature of about -25 °C;

28.5 weight percent trans-HFC-1234ze and 71.5 weight percent propane having a vapor pressure of about 30.3 psia (209 kPa) at a temperature of about -25 °C;

88.6 weight percent trans-HFC-1234ze and 11.4 weight percent n-butane having a vapor pressure of about 11.9 psia (82 kPa) at a temperature of about -25 °C;

77.9 weight percent trans-HFC-1234ze and 22.1 weight percent isobutane having a vapor pressure of about 12.9 psia (89 kPa) at a temperature of about -25 °C;

84.1 weight percent trans-HFC-1234ze and 15.9 weight percent dimethylether having a vapor pressure of about 10.8 psia (74 kPa) at a temperature of about -25 °C;

34.3 weight percent trans-HFC-1234ze and 65.7 weight percent CF_3SCF_3 having a vapor pressure of about 12.7 psia (88 kPa) at a temperature of about -25 °C;

7.1 weight percent trans-HFC-1234ze, 73.7 weight percent HFC-1243zf, and 19.2 weight percent HFC-227ea having a vapor pressure of about 13.1 psia (90.4 kPa) at a temperature of about -25 °C;

9.5 weight percent trans-HFC-1234ze, 81.2 weight percent HFC-1243zf, and 9.3 weight percent n-butane having a vapor pressure of about 13.5 psia (92.9 kPa) at a temperature of about -25 °C;

3.3 weight percent trans-HFC-1234ze, 77.6 weight percent HFC-1243zf, and 19.1 weight percent isobutane having a vapor pressure of about 14.3 psia (98.3 kPa) at a temperature of about -25 °C;

2.6 weight percent trans-HFC-1234ze, 70.0 weight percent HFC-1243zf, and 27.4 weight percent dimethylether having a vapor pressure of about 12.0 psia (82.9 kPa) at a temperature of about -25 °C;

52.0 weight percent trans-HFC-1234ze, 42.9 weight percent HFC-134, and 5.1 weight percent HFC-152a having a vapor pressure of about 12.4 psia (85.3 kPa) at a temperature of about -25 °C;

30.0 weight percent trans-HFC-1234ze, 43.2 weight percent HFC-134, and 26.8 weight percent HFC-227ea having a vapor pressure of about 12.6 psia (86.9 kPa) at a temperature of about -25 °C;

27.7 weight percent trans-HFC-1234ze, 54.7 weight percent HFC-134, and 17.7 weight percent dimethylether having a vapor pressure of about 9.8 psia (67.3 kPa) at a temperature of about -25 °C;

5.4 weight percent trans-HFC-1234ze, 80.5 weight percent HFC-152a, and 14.1 weight percent n-butane having a vapor pressure of about 15.4 psia (106 kPa) at a temperature of about -25 °C;

59.1 weight percent trans-HFC-1234ze, 16.4 weight percent HFC-152a, and 24.5 weight percent dimethylether having a vapor pressure of about 10.8 psia (74.5 kPa) at a temperature of about -25 °C;

40.1 weight percent trans-HFC-1234ze, 48.5 weight percent HFC-227ea, and 11.3 weight percent n-butane having a vapor pressure of about 12.6 psia (86.9 kPa) at a temperature of about -25 °C;

68.1 weight percent trans-HFC-1234ze, 13.0 weight percent n-butane, and 18.9 weight percent dimethylether having a vapor pressure of about 11.3 psia (77.8 kPa) at a temperature of about -25 °C;

55.5 weight percent trans-HFC-1234ze, 28.7 weight percent isobutane, and 15.8 weight percent dimethylether having a vapor pressure of about 12.4 psia (85.4 kPa) at a temperature of about -25 °C;

37.7 weight percent trans-HFC-1234ze, 1.1 weight percent isobutane, and 61.7 weight percent CF_3SCF_3 having a vapor pressure of about 12.7 psia (87.3 kPa) at a temperature of about -25 °C;

20.9 weight percent cis-HFC-1234ze and 79.1 weight percent HFC-236ea having a vapor pressure of about 30.3 psia (209 kPa) at a temperature of about 25 °C;

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76.2 weight percent cis-HFC-1234ze and 23.8 weight percent HFC-245fa having a vapor pressure of about 26.1 psia (180 kPa) at a temperature of about 25 °C;

51.4 weight percent cis-HFC-1234ze and 48.6 weight percent n-butane having a vapor pressure of about 6.1 psia (41.9 kPa) at a temperature of about -25 °C;

26.2 weight percent cis-HFC-1234ze and 73.8 weight percent isobutane having a vapor pressure of about 8.7 psia (60.3 kPa) at a temperature of about -25 °C;

86.6 weight percent cis-HFC-1234ze and 13.4 weight percent 2-methylbutane having a vapor pressure of about 27.2 psia (188 kPa) at a temperature of about 25 °C; and

92.9 weight percent cis-HFC-1234ze and 7.1 weight percent n-pentane having a vapor pressure of about 26.2 psia (181 kPa) at a temperature of about 25 °C.

3. The composition of claim 1, further comprising a lubricant selected from the group consisting of polyol esters, polyalkylene glycols, polyvinyl ethers, mineral oil, alkylbenzenes, synthetic paraffins, synthetic napthenes, and poly(alpha)olefins.

4. The composition of claim 1, further comprising a tracer selected from the group consisting of hydrofluorocarbons, deuterated hydrocarbons, deuterated hydrofluorocarbons, perfluorocarbons, fluoroethers, brominated compounds, iodated compounds, alcohols, aldehydes, ketones, nitrous oxide (N_2O) and combinations thereof.

5. The composition of claim 1, further comprising a compatibilizer selected from the group consisting of:

a) polyoxyalkylene glycol ethers represented by the formula $R^1[(OR^2)_xOR^3]_y$, wherein: x is an integer from 1 to 3; y is an integer from 1 to 4; R^1 is selected from hydrogen and aliphatic hydrocarbon radicals having 1 to 6 carbon atoms and y bonding sites; R^2 is selected from aliphatic hydrocarbylene radicals having from 2 to 4 carbon atoms; R^3 is selected from hydrogen, and aliphatic and alicyclic hydrocarbon radicals

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having from 1 to 6 carbon atoms; at least one of R^1 and R^3 is selected from said hydrocarbon radicals; and wherein said polyoxyalkylene glycol ethers have a molecular weight of from about 100 to about 300 atomic mass units;

b) amides represented by the formulae $R^1C(O)NR^2R^3$ and cyclo-$[R^4CON(R^5)\text{-}]$, wherein R^1, R^2, R^3 and R^5 are independently selected from aliphatic and alicyclic hydrocarbon radicals having from 1 to 12 carbon atoms, and at most one aromatic radical having from 6 to 12 carbon atoms; R^4 is selected from aliphatic hydrocarbylene radicals having from 3 to 12 carbon atoms; and wherein said amides have a molecular weight of from about 100 to about 300 atomic mass units;

c) ketones represented by the formula $R^1C(O)R^2$, wherein R^1 and R^2 are independently selected from aliphatic, alicyclic and aryl hydrocarbon radicals having from 1 to 12 carbon atoms, and wherein said ketones have a molecular weight of from about 70 to about 300 atomic mass units;

d) nitriles represented by the formula R^1CN, wherein R^1 is selected from aliphatic, alicyclic or aryl hydrocarbon radicals having from 5 to 12 carbon atoms, and wherein said nitriles have a molecular weight of from about 90 to about 200 atomic mass units;

e) chlorocarbons represented by the formula RCl_x, wherein; x is 1 or 2; R is selected from aliphatic and alicyclic hydrocarbon radicals having from 1 to 12 carbon atoms; and wherein said chlorocarbons have a molecular weight of from about 100 to about 200 atomic mass units;

f) aryl ethers represented by the formula R^1OR^2, wherein: R^1 is selected from aryl hydrocarbon radicals having from 6 to 12 carbon atoms; R^2 is selected from aliphatic hydrocarbon radicals having from 1 to 4 carbon atoms; and wherein said aryl ethers have a molecular weight of from about 100 to about 150 atomic mass units;

g) 1,1,1-trifluoroalkanes represented by the formula CF_3R^1, wherein R^1 is selected from aliphatic and alicyclic hydrocarbon radicals having from about 5 to about 15 carbon atoms;

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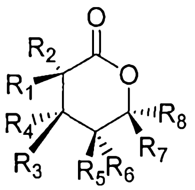
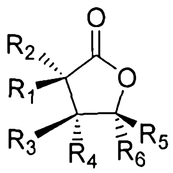
h) fluoroethers represented by the formula $R^1OCF_2CF_2H$, wherein R^1 is selected from aliphatic, alicyclic, and aromatic hydrocarbon radicals having from about 5 to about 15 carbon atoms; or wherein said fluoroethers are derived from fluoroolefins and polyols, wherein said fluoroolefins are of the type CF_2=CXY, wherein X is hydrogen, chlorine or fluorine, and Y is chlorine, fluorine, CF_3 or OR_f, wherein R_f is CF_3, C_2F_5, or C_3F_7; and said polyols are linear or branched, wherein said linear polyols are of the type $HOCH_2(CHOH)_x(CRR')_yCH_2OH$, wherein R and R' are hydrogen, CH_3 or C_2H_5, x is an integer from 0-4, y is an integer from 0-3 and z is either zero or 1, and said branched polyols are of the type $C(OH)_t(R)_u(CH_2OH)_v[(CH_2)_mCH_2OH]_w$, wherein R may be hydrogen, CH_3 or C_2H_5, m is an integer from 0 to 3, t and u are 0 or 1, v and w are integers from 0 to 4, and also wherein t + u + v + w = 4; and

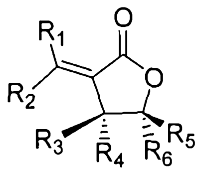
i) lactones represented by structures [B], [C], and [D]:



[B]



[C]



[D]

wherein, R_1 through R_8 are independently selected from hydrogen, linear, branched, cyclic, bicyclic, saturated and unsaturated hydrocarbyl radicals; and the molecular weight is from about 100 to about 300 atomic mass units; and

j) esters represented by the general formula $R^1CO_2R^2$, wherein R^1 and R^2 are independently selected from linear and cyclic, saturated and unsaturated, alkyl and aryl radicals; and wherein said esters have a molecular weight of from about 80 to about 550 atomic mass units.

6. The composition of claim 1, further comprising at least one ultra-violet fluorescent dye selected from the group consisting of

naphthalimides, perylenes, coumarins, anthracenes, phenanthracenes, xanthenes, thioxanthenes, naphthoxanthenes, fluoresceins, derivatives of said dye and combinations thereof.

7. The composition of claim 6, further comprising at least one solubilizing agent selected from the group consisting of hydrocarbons, dimethylether, polyoxyalkylene glycol ethers, amides, ketones, nitriles, chlorocarbons, esters, lactones, aryl ethers, hydrofluoroethers, and 1,1,1-trifluoroalkanes.

8. The composition of claim 1, further comprising a stabilizer, water scavenger, or odor masking agent.

9. The composition of claim 8, wherein said stabilizer is selected from the group consisting of nitromethane, hindered phenols, hydroxylamines, thiols, phosphites and lactones.

10. A method of producing cooling, said method comprising: evaporating said composition of claim 1 in the vicinity of a body to be cooled and thereafter condensing said composition.

11. A method of producing heat, said method comprising: condensing said composition of claim 1 in the vicinity of a body to be heated and thereafter evaporating said composition.

12. A method for improving oil-return to the compressor in a compression refrigeration, air-conditioning or heat pump apparatus, said method comprising using the composition of claim 3 in said apparatus.

13. A method for replacing a high global warming potential (GWP) refrigerant in a refrigeration, air-conditioning, or heat pump apparatus, wherein said high GWP refrigerant is selected from the group consisting of R134a, R22, R123, R11, R245fa, R114, R236fa, R124, R12, R410A, R407C, R417A, R422A, R507A, R502, and R404A, said method comprising providing the composition of claim 1 to said refrigeration, air-conditioning, or heat pump

apparatus that uses, used or is designed to use said high GWP refrigerant.

14. A method of using the composition of claim 1 as a heat transfer fluid composition, said process comprising transporting said composition from a heat source to a heat sink.

15. A refrigeration, air-conditioning, or heat pump apparatus containing a composition as claimed in any one of claims 1 to 9.

16. The refrigeration, air-conditioning, or heat pump apparatus of claim 15 comprising a mobile air-conditioning apparatus.

17. A method of forming a foam comprising:
(a) adding to a foamable composition the composition of any one of claims 1 to 9; and
(b) reacting the foamable composition under conditions effective to form a foam.

18. A process for producing aerosol products comprising the step of adding a composition of any one of claims 1 to 9 to active ingredients in an aerosol container, wherein said composition functions as a propellant.

19. The composition of any one of claims 1 to 9, substantially as hereinbefore described with reference to any of the Examples.

20. The method of any one of claims 10 to 14 and 17 or the process of claim 18, substantially as hereinbefore described with reference to any of the Examples.