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Szabadalmi Ügyvivő Iroda Kft., Budapest(54) **Fluorolefint tartalmazó kompozíciók**

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(54) **Compositions comprising a fluoroolefin**

Zusammensetzungen mit einem Fluoroolefin

Compositions comprenant une fluorooléfine

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(56) References cited:
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Description**CROSS REFERENCE(S) TO RELATED APPLICATION(S)**

5 **[0001]** This application claims the priority benefit of U.S. Provisional Application 60/658,543, filed March 4, 2005, and U.S. Provisional Application 60/710,439, filed August 23, 2005, and U.S. Provisional Application 60/732,769, filed November 1, 2005.

BACKGROUND OF THE INVENTION

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1. Field of the Invention.

[0002] 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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2. Description of Related Art.

20 **[0003]** 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.

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[0004] 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.

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[0005] Currently proposed replacement refrigerants for HFC-134a include HFC-152a, pure hydrocarbons such as butane or propane, or "natural" refrigerants such as CO₂. Many of these suggested replacements are toxic, flammable, and/or have low energy efficiency. Therefore, new alternative refrigerants are being sought.

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[0006] The object 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.

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[0007] US 2004/0127383 discloses azeotropic compositions comprising pentafluoropropene (HFO-1225) and one or more of 3,3,3-trifluoropropene (HFO-1243zf), 1,1-difluoroethane (HFC-152a) and trans 1,3,3,3-tetrafluoropropene (HFO-1234ze).

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[0008] US 3,723,318 discloses aerosol propellants and refrigerants based on 3,3,3-trifluoro-propene (HFO-1243zf).

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BRIEF SUMMARY OF THE INVENTION

[0009] The present invention relates to a composition comprising 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 and CF₃SCF₃.

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[0010] The present invention further relates to a composition selected from the group consisting of: HFC-1234yf, dimethylether and CF₃I; HFC-1234yf, HFC-32 and CF₃I; HFC-1234yf, HFC-32, HFC-125 and CF₃I; and HFC-1234yf, HFC-32, HFC-134a and CF₃I.

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[0011] The present invention further relates to a composition comprising:

(a) at least one lubricant selected from the group consisting of polyol esters, polyalkylene glycol, polyvinyl ethers, mineral oils, alkylbenzenes, synthetic paraffins, synthetic naphthenes, and poly(alpha)olefins; and

(b) an HFC-1234yf composition as defined above.

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[0012] The present invention further relates to a composition comprising:

a) an HFC-1234yf composition as defined above; and

b) a tracer selected from the group consisting of hydrofluorocarbons, deuterated hydrocarbons, deuterated hydrofluorocarbons, perfluorocarbons, fluoroethers, brominated compounds, iodated compounds, alcohols, aldehydes, ketones, nitrous oxide (N₂O) and combinations thereof.

5 [0013] The present invention further relates to a composition comprising:

(a) 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; and

10 (b) a HFC-1234yf composition as defined above.

[0014] 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, R123, R11, R245fa, R114, R236fa, R124, R12, R410A, R407C, R417A, R422A, R507A, R502, and R404A, said method comprising providing an HFC-1234yf composition as defined above to said refrigeration, air-conditioning, or heat pump apparatus that uses, used or designed to use said high GWP refrigerant.

DETAILED DESCRIPTION OF THE INVENTION

20 [0015] 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, bis(trifluoromethyl)sulfide, CF₃I, or CO₂. The fluoroolefin compounds and other components of the present inventive compositions are listed in Table 1.

25 **TABLE 1**

Compound	Chemical name	Chemical formula
HFC-1234yf	2,3,3,3-tetrafluoropropene	CF ₃ CF=CH ₂
HFC-1234ye	1,2,3,3-tetrafluoropropene	CHF ₂ CF=CHF
HFC-1243zf	3,3,3-trifluoropropene	CF ₃ CH=CH ₂
HFC-32	difluoromethane	CH ₂ F ₂
HFC-125	pentafluoroethane	CF ₃ CHF ₂
HFC-134	1,1,2,2-tetrafluoroethane	CHF ₂ CHF ₂
HFC-134a	1,1,1,2-tetrafluoroethane	CH ₂ FCF ₃
HFC-143a	1,1,1-trifluoroethane	CH ₃ CF ₃
HFC-152a	1,1-difluoroethane	CHF ₂ CH ₃
HFC-161	fluoroethane	CH ₃ CH ₂ F
HFC-227ea	1,1,1,2,3,3,3-heptafluoropropane	CF ₃ CHF ₂ CF ₃
HFC-236ea	1,1,1,2,3,3-hexafluoropropane	CF ₃ CHFCHF ₂
HFC-236fa	1,1,1,3,3,3-hexafluoroethane	CF ₃ CH ₂ CF ₃
HFC-245fa	1,1,1,3,3-pentafluoropropane	CF ₃ CH ₂ CHF ₂
HFC-365mfc	1,1,1,3,3-pentafluorobutane	CF ₃ CH ₂ CH ₂ CHF ₂
	propane	CH ₃ CH ₂ CH ₃
	n-butane	CH ₃ CH ₂ CH ₂ CH ₃
i-butane	isobutane	CH ₃ CH(CH ₃)CH ₃
	2-methylbutane	CH ₃ CH(CH ₃)CH ₂ CH ₃
	n-pentane	CH ₃ CH ₂ CH ₂ CH ₂ CH ₃
	cyclopentane	cyclo-(CH ₂) ₅

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(continued)

Compound	Chemical name	Chemical formula
DME	dimethylether	CH ₃ OCH ₃
CF ₃ SCF ₃	bis(trifluoromethyl)sulfide	CF ₃ SCF ₃
	iodotrifluoromethane	CF ₃ I

[0016] The individual components listed in Table 1 may be prepared by methods known in the art.

[0017] The fluoroolefin compound HFC-1234ye used in the compositions of the present invention 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.

[0018] 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.

[0019] The present invention further provides compositions as listed in Table 2.

TABLE 2

Components	Concentration ranges (wt%)		
	Preferred	More preferred	Most preferred
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-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-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-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-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	

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(continued)

Components	Concentration ranges (wt%)		
	Preferred	More preferred	Most preferred
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/DNIE	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 ₃ I	1-98/1-98/1-98	10-80/1-20/10-80	
HFC-1234yf/DME/CF ₃ SCF ₃	1-98/1-40/1-80	10-80/1-20/10-70	
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 ₃ I	1-96/1-96/1-96/1-96/1-96	1-70/1-60/1-70/1-60/1-60	
HFC-1234yf/HFC-32/CF ₃ I	1-98/1-98/1-98	10-80/1-70/1-80	
HFC-1234yf/HFC-32/HFC-134a/CF ₃ I	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	
HFC-1234yf/HFC-32/HFC-125/CF ₃ I	1-97/1-97/1-97/1-97	10-80/5-70/10-80/5-80	

[0020] 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.

[0021] 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.

[0022] 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

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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, 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.

[0023] 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

[0024] 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

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(continued)

Component A	Component B	Component C	Wt% A	Wt% B	Wt% C	Pres (psi)	Pres (kPa)	Temp (°C)
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 ₃ I	16.3	10.0	73.7	15.65	108	-25
HFC-1234yf	DME	CF ₃ SCF ₃	34.3	10.5	55.2	14.57	100	-25

[0025] 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-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

[0026] 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-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-125/HFC-1234yf/isobutane	80-98/1-19/1-10	25
HFC-32/HFC-125/HFC-1234yf	1-98/1-98/1-55	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

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(continued)

Components	Near-azeotrope range (weight percent)	Temp (°C)
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 ₃ I	1-98/1-98/1-98	-25
HFC-1234yf/DME/CF ₃ SCF ₃	1-98/1-40/1-80	-25

[0027] 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.

[0028] A non-azeotropic composition may have certain advantages over azeotropic 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.

[0029] 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.

[0030] 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.

[0031] 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.

[0032] 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.

[0033] 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.

[0034] Such impurities may be removed sufficiently to allow reuse of the refrigerant blend or refrigerant blend component without adversely effecting the performance or equipment within which the refrigerant blend or refrigerant blend component will be used.

[0035] 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.

[0036] 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.

[0037] 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).

[0038] 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.

[0039] The compositions of the present invention may further comprise a lubricant.

[0040] 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 naphthenes, 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).

[0041] Lubricants of the present invention further comprise those that have been designed for use with hydrofluoro-

carbon 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.

[0042] 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.

[0043] 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 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.

[0044] 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.

[0045] 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.

[0046] 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 (N₂O) 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. Published Patent application no. US 2005/0230657.

[0047] 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 ₃ CD ₃
Propane-d8	CD ₃ CD ₂ CD ₃
HFC-32-d2	CD ₂ F ₂
HFC-134a-d2	CD ₂ FCF ₃
HFC-143a-d3	CD ₃ CF ₃
HFC-125-d	CDF ₂ CF ₃
HFC-227ea-d	CF ₃ CDFCF ₃
HFC-227ca-d	CF ₃ CF ₂ CDF ₂
HFC-134-d2	CDF ₂ CDF ₂
HFC-236fa-d2	CF ₃ CD ₂ CF ₃
HFC-245cb-d3	CF ₃ CF ₂ CD ₃

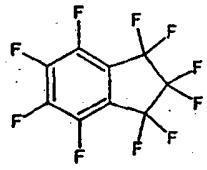
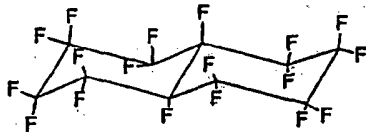
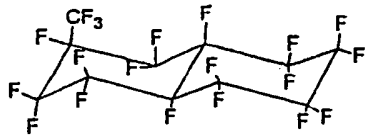
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(continued)

Compound	Structure
Deuterated hydrocarbons and hydrofluorocarbons	
HFC-263fb-d2*	CF ₃ CD ₂ CH ₃
HFC-263fb-d3	CF ₂ CH ₂ CD ₃
Fluoroethers	
HFOC-125E	CHF ₂ OCF ₃
HFOC-134aE	CH ₂ FOCF ₃
HFOC-143aE	CH ₃ OCF ₃
HFOC-227eaE	CF ₃ OCHF ₂ CF ₃
HFOC-236faE	CF ₃ OCH ₂ CF ₃
HFOC-245faEβγ or HFOC-245faEαβ	CHF ₂ OCH ₂ CF ₃ (or CHF ₂ CH ₂ OCF ₃)
HFOC-245cbEβγ or HFOC-245cbαβ	CH ₃ OCF ₂ CF ₃ (or CH ₃ CF ₂ OCF ₃)
HFE-42-11mcc (or Freon® E1)	CF ₃ CF ₂ CF ₂ OCHF ₂ CF ₃
Freon® E2	CF ₃ CF ₂ CF ₂ OCF(CF ₃)CF ₂ OCHF ₂ CF ₃
Hydrofluorocarbons	
HFC-23	CHF ₃
HFC-161	CH ₃ CH ₂ F
HFC-152a	CH ₃ CHF ₂
HFC-134	CHF ₂ CHF ₂
HFC-227ea	CF ₃ CHF ₂ CF ₃
HFC-227ca	CHF ₂ CF ₂ CF ₃
HFC-236cb	CH ₂ FCF ₂ CF ₃
HFC-236ea	CF ₃ CHFCHF ₂
HFC-236fa	CF ₃ CH ₂ CF ₃
HFC-245cb	CF ₃ CF ₂ CH ₃
HFC-245fa	CHF ₂ CH ₂ CF ₃
HFC-254cb	CHF ₂ CF ₂ CH ₃
HFC-254eb	CF ₃ CHFCH ₃
HFC-263fb	CF ₃ CH ₂ CH ₃
HFC-272ca	CH ₃ CF ₂ CH ₃
HFC-281ea	CH ₃ CHFCH ₃
HFC-281fa	CH ₂ FCH ₂ CH ₃
HFC-329p	CHF ₂ CF ₂ CF ₂ CF ₃
HFC-329mmz	(CH ₃) ₂ CHCF ₃
HFC-338mf	CF ₃ CH ₂ CF ₂ CF ₃
HFC-338pcc	CHF ₂ CF ₂ CF ₂ CHF ₂
HFC-347s	CH ₃ CF ₂ CF ₂ CF ₃
HFC-43-10mee	CF ₃ CNFCCHF ₂ CF ₃

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(continued)

Perfluorocarbons		
5	PFC-116	CF_3CF_3
	PFC-C216	$\text{Cyclo}(-\text{CF}_2\text{CF}_2\text{CF}_2-)$
	HFC-218	$\text{CF}_3\text{CF}_2\text{CF}_3$
	PFC-C318	$\text{Cyclo}(-\text{CF}_2\text{CF}_2\text{CF}_2\text{CF}_2-)$
10	PFC-31-10mc	$\text{CF}_3\text{CF}_2\text{CF}_2\text{CF}_3$
	PFC-31-10my	$(\text{CF}_3)_2\text{CFCF}_3$
	PFC-C51-12mycm	$\text{Cyclo}(-\text{CF}(\text{CF}_3)\text{CF}_2\text{CF}(\text{CF}_3)\text{CF}_2-)$
15	PFC-C51-12mym, trans	$\text{Cyclo}(-\text{CF}_2\text{CF}(\text{CF}_3)\text{CF}(\text{CF}_3)\text{CF}_2-)$
	PFC-C51-12mym, cis	$\text{Cyclo}(-\text{CF}_2\text{CF}(\text{CF}_3)\text{CF}(\text{CF}_3)\text{CF}_2-)$
	Perfluoromethylcyclo-pentane	$\text{Cyclo}(-\text{CF}_2\text{CF}_2(\text{CF}_3)\text{CF}_2\text{CF}_2\text{CF}_2-)$
	Perfluoromethylcyclo-hexane	$\text{Cyclo}(-\text{CF}_2\text{CF}_2(\text{CF}_3)\text{CF}_2\text{CF}_2\text{CF}_2\text{CF}_2-)$
20	Perfluorodimethylcyclo-hexane (ortho, meta, or para)	$\text{Cyclo}(-\text{CF}_2\text{CF}_2(\text{CF}_3)\text{CF}_2\text{CF}_2(\text{CF}_3)\text{CF}_2-)$
	Perfluoroethylcyclohexane	$\text{Cyclo}(-\text{CF}_2\text{CF}_2(\text{CF}_2\text{CF}_3)\text{CF}_2\text{CF}_2\text{CF}_2\text{CF}_2-)$
25	Perfluoroindan	C_9F_{10} (see structure below)
		
30	Perfluorotrimethylcyclo-hexane (all possible isomers)	$\text{Cyclo}(-\text{CF}_2(\text{CF}_3)\text{CF}_2(\text{CF}_3)\text{CF}_2\text{CF}_2(\text{CF}_3)\text{CF}_2-)$
	Perfluoroisopropylcyclo-hexane	$\text{Cyclo}(\text{CF}_2\text{CF}_2(\text{CF}_2(\text{CF}_3)_2)\text{CF}_2\text{CF}_2\text{CF}_2\text{CF}_2-)$
35	Perfluorodecalin (cis or trans, trans shown)	$\text{C}_{10}\text{F}_{18}$ (see structure below)
		
40	Perfluoromethyldecalin (cis or trans and all additional possible isomers)	$\text{C}_{11}\text{F}_{20}$ (see structure below)
45		
Brominated compounds		
	Bromoethane	CH_3Br
50	Bromofluoromethane	CH_2FBr
	Bromodifluoromethane	CHF_2Br
	Dibromofluoromethane	CHFBr_2
	Tribromomethane	CHBr_3
55	Bromoethane	$\text{CH}_3\text{CH}_2\text{Br}$
	Bromoethene	$\text{CH}_2=\text{CHBr}$

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(continued)

Brominated compounds		
5	1,2-dibromoethane	$\text{CH}_2\text{BrCH}_2\text{Br}$
	1-bromo-1,2-difluoroethene	$\text{CFBr}=\text{CHF}$
Iodated compounds		
	Iodotrifluoromethane	CF_3I
10	Difluoriodomethane	CHF_2I
	Fluoriodomethane	$-\text{CH}_2\text{FI}$
	1,1,2-trifluoro-1-iodoethane	$\text{CF}_2\text{ICH}_2\text{F}$
15	1,1,2,2-tetrafluoro-1-iodoethane	CF_2ICHF_2
	1,1,2,2-tetrafluoro-1,2-diiodoethane	$\text{CF}_2\text{IGF}_2\text{I}$
	Iodopentafluorobenzene	$\text{C}_6\text{F}_5\text{I}$
Alcohols		
20	Ethanol	$\text{CH}_3\text{CH}_2\text{OH}$
	n-propanol	$\text{CH}_3\text{CH}_2\text{CH}_2\text{OH}$
	Isopropanol	$\text{CH}_3\text{CH}(\text{OH})\text{CH}_3$
Aldehydes and Ketones		
25	Acetone (2-propanone) Acetone	$\text{CH}_3\text{C}(\text{O})\text{CH}_3$
	n-propanal	$\text{CH}_3\text{CH}_2\text{CHO}$
	n-butanal	$\text{CH}_3\text{CH}_2\text{CH}_2\text{CHO}$
30	Methyl ethyl ketone (2-butanone)	$\text{CH}_3\text{C}(\text{O})\text{CH}_2\text{CH}_3$
Other		
	Nitrous oxide	N_2O

35 **[0048]** The compounds listed in Table 7 are available commercially (from chemical supply houses) or may be prepared by processes known in the art.

40 **[0049]** 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.

45 **[0050]** 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.

50 **[0051]** 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.

55 **[0052]** 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.

[0053] Hydrofluorocarbon refrigerants are generally not compatible with convention refrigeration lubricants such as

mineral oils, alkylbenzenes, synthetic paraffins, synthetic naphthenes and poly(alpha)olefins. Many replacement lubricants have been proposed, however, the polyalkylene 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.

[0054] The compatibilizers of the present invention improve solubility of the hydrofluorocarbon refrigerants in conventional refrigeration lubricants and thus improve oil return to the compressor.

[0055] 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 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.

[0056] Representative polyoxyalkylene glycol ether compatibilizers include but are not limited to: $CH_3OCH_2CH(CH_3)O(H \text{ or } CH_3)$ (propylene glycol methyl (or dimethyl) ether), $CH_3O[CH_2CH(CH_3)O]_2(H \text{ or } CH_3)$ (dipropylene glycol methyl (or dimethyl) ether), $CH_3O[CH_2CH(CH_3)O]_3(H \text{ or } CH_3)$ (tripropylene glycol methyl (or dimethyl) ether), $C_2H_5OCH_2CH(CH_3)O(H \text{ or } C_2H_5)$ (propylene glycol ethyl (or diethyl) ether), $C_2H_5O[CH_2CH(CH_3)O]_2(H \text{ or } C_2H_5)$ (dipropylene glycol ethyl (or diethyl) ether), $C_2H_5O[CH_2CH(CH_3)O]_3(H \text{ or } C_2H_5)$ (tripropylene glycol ethyl (or diethyl) ether), $C_3H_7OCH_2CH(CH_3)O(H \text{ or } C_3H_7)$ (propylene glycol n-propyl (or di-n-propyl) ether), $C_3H_7O[CH_2CH(CH_3)O]_2(H \text{ or } C_3H_7)$ (dipropylene glycol n-propyl (or di-n-propyl) ether), $C_3H_7O[CH_2CH(CH_3)O]_3(H \text{ or } C_3H_7)$ (tripropylene glycol n-propyl (or di-n-propyl) ether), $C_4H_9OCH_2CH(CH_3)OH$ (propylene glycol n-butyl ether), $C_4H_9O[CH_2CH(CH_3)O]_2(H \text{ or } C_4H_9)$ (dipropylene glycol n-butyl (or di-n-butyl) ether), $C_4H_9O[CH_2CH(CH_3)O]_3(H \text{ or } C_4H_9)$ (tripropylene glycol n-butyl (or di-n-butyl) ether), $(CH_3)_3COCH_2CH(CH_3)OH$ (propylene glycol t-butyl ether), $(CH_3)_3CO[CH_2CH(CH_3)O]_2(H \text{ or } (CH_3)_3)$ (dipropylene glycol t-butyl (or di-t-butyl) ether), $(CH_3)_3CO[CH_2CH(CH_3)O]_3(H \text{ or } (CH_3)_3)$ (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 ($C_2H_5C(CH_2O)(CH_2)_3CH_3$) and trimethylolpropane di-n-butyl ether ($C_2H_5C(CH_2OC(CH_2)_3CH_3)_2CH_2OH$).

[0057] Amide compatibilizers of the present invention comprise those represented by the formulae $R^1C(O)NR^2R^3$ and cyclo- $[R^4C(O)N(R^5)]_n$, 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

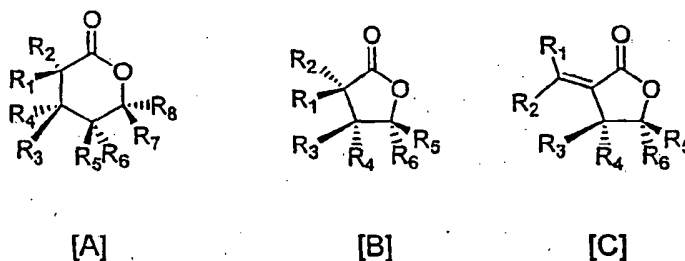
[0063] Chlorocarbon compatibilizers of the present invention comprise chlorocarbons represented by the formula RCI_x , wherein; x is selected from the integers 1 or 2; R is selected from aliphatic and alicyclic hydrocarbon radicals having 1 to 12 carbon atoms; and wherein said chlorocarbons have a molecular 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 RCI_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.

[0064] 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.

[0065] 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.

[0066] Representative esters include but are not limited to: $(CH_3)_2CHCH_2OOC(CH_2)_{2-4}OCOCH_2CH(CH_3)_2$ (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.

[0067] Lactone compatibilizers of the present invention comprise lactones, represented by structures [A], [B], and [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 through 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 through 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.

[0068] 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

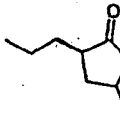
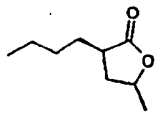
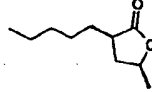
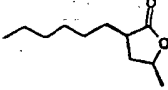
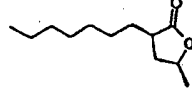
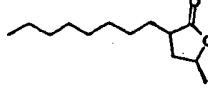
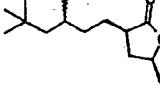
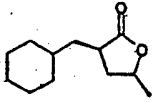
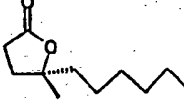
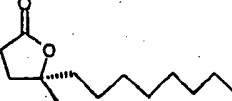
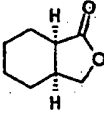
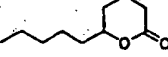
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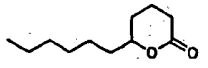
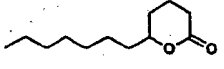
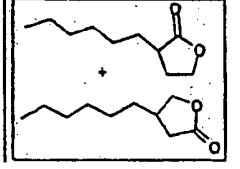
	Additive	Molecular Structure	Molecular Formula	Molecular Weight (amu)
5	(E,Z)-3-pentylidene-5-methyl-dihydro-furan-2-one		C ₁₀ H ₁₆ O ₂	168
10	(E,Z)-3-Hexylidene-5-methyl-dihydro-furan-2-one		C ₁₁ H ₁₈ O ₂	182
15	(E,Z)-3-Heptylidene-5-methyl-dihydro-furan-2-one		C ₁₂ H ₂₀ O ₂	196
20	(E,Z)-3-octylidene-5-methyl-dihydro-furan-2-one		C ₁₃ H ₂₂ O ₂	210
25	(E,Z)-3-nonylidene-5-methyl-dihydro-furan-2-one		C ₁₄ H ₂₄ O ₂	224
30	(E,Z)-3-decylidene-5-methyl-dihydro-furan-2-one		C ₁₅ H ₂₆ O ₂	238
35	(E,Z)-3-(3,5,5-trimethylhexylidene)-5-methyl-dihydrofuran-2-one		C ₁₄ H ₂₄ O ₂	224
40	(E,Z)-3-cyclohexylmethylidene-5-methyl-dihydrofuran-2-one		C ₁₂ H ₁₈ O ₂	194
45	<i>gamma</i> -octalactone		C ₈ H ₁₄ O ₂	142
50	<i>gamma</i> -nonalactone		C ₉ H ₁₆ O ₂	156
55	<i>gamma</i> -decalactone		C ₁₀ H ₁₈ O ₂	170
	<i>gamma</i> -undecalactone		C ₁₁ H ₂₀ O ₂	184
	<i>gamma</i> -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
	<i>cis</i> -3-ethyl-5-methyl-dihydro-furan-2-one		C ₇ H ₁₂ O ₂	128

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(continued)

	Additive	Molecular Structure	Molecular Formula	Molecular Weight (amu)
5	<i>cis</i> -(3-propyl-5-methyl)-dihydro-furan-2-one		C ₈ H ₁₄ O ₂	142
10	<i>cis</i> -(3-butyl-5-methyl)-dihydro-furan-2-one		C ₉ H ₁₆ O ₂	156
15	<i>cis</i> -(3-pentyl-5-methyl)-dihydro-furan-2-one		C ₁₀ H ₁₈ O ₂	170
20	<i>cis</i> -3-hexyl-5-methyl-dihydro-furan-2-one		C ₁₁ H ₂₀ O ₂	184
25	<i>cis</i> -3-heptyl-5-methyl-dihydro-furan-2-one		C ₁₂ H ₂₂ O ₂	198
30	<i>cis</i> -3-octyl-5-methyl-dihydro-furan-2-one		C ₁₃ H ₂₄ O ₂	212
35	<i>cis</i> -3-(3,5,5-trimethylhexyl)-5-methyl-dihydro-furan-2-one		C ₁₄ H ₂₆ O ₂	226
40	<i>cis</i> -3-cyclohexylmethyl-5-methyl-dihydro-furan-2-one		C ₁₂ H ₂₀ O ₂	196
45	5-methyl-5-hexyl-dihydro-furan-2-one		C ₁₁ H ₂₀ O ₂	184
50	5-methyl-5-octyl-dihydro-furan-2-one		C ₁₃ H ₂₄ O ₂	212
55	Hexahydro-isobenzofuran-1-one		C ₈ H ₁₂ O ₂	140
	<i>delta</i> -decalactone		C ₁₀ H ₁₈ O ₂	170

(continued)

Additive	Molecular Structure	Molecular Formula	Molecular Weight (amu)
<i>delta</i> -undecalactone		C ₁₁ H ₂₀ O ₂	184
<i>delta</i> -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

[0069] 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)dlhydrofuran-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. Published patent application no. US 2006/0030719.

[0070] Aryl ether compatibilizers of the present invention further comprise aryl ethers represented by the formula R¹OR², wherein: R¹ is selected from aryl hydrocarbon radicals having from 6 to 12 carbon atoms; R² 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 R¹ aryl radicals in the general formula R¹OR² includes phenyl, biphenyl, cumenyl, mesityl, tolyl, xylyl, naphthyl and pyridyl. Representative R² aliphatic hydrocarbon radicals in the general formula R¹OR² 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-dimethoxybenzene, ethyl phenyl ether and butyl phenyl ether.

[0071] Fluoroether compatibilizers of the present invention comprise those represented by the general formula R¹OCF₂CF₂H, wherein R¹ 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: C₈H₁₇OCF₂CF₂H and C₆H₁₃OCF₂CF₂H. It should be noted that if the refrigerant is a fluoroether, then the compatibilizer may not be the same fluoroether.

[0072] Fluoroether compatibilizers may further comprise ethers derived from fluoroolefins and polyols. The fluoroolefins may be of the type CF₂=CXY, wherein X is hydrogen, chlorine or fluorine, and Y is chlorine, fluorine, CF₃ or OR_f, wherein R_f is CF₃, C₂F₅, or C₃F₇. Representative fluoroolefins are tetrafluoroethylene, chlorotrifluoroethylene, hexafluoropropylene, and perfluoromethylvinyl ether. The polyols may be linear or branched. Linear polyols may be of the type HOCH₂(CHOH)_x(CRR')_yCH₂OH, wherein R and R' are hydrogen, or CH₃, or C₂H₅ 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(CH₂OH)_v[(CH₂)_mCH₂OH]_w, wherein R may be hydrogen, CH₃ or C₂H₅, 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.

[0073] 1,1,1-Trifluoroalkane compatibilizers of the present invention comprise 1,1,1-trifluoroalkanes represented by the general formula CF₃R¹, wherein R¹ 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.

[0074] 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.

[0075] 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.

[0076] 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 naphthenes, and poly(alpha)olefins, wherein said method com-

prises 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, nitrates, ketones, chlorocarbons, esters, lactones, aryl ethers, fluoroethers and 1,1,1-trifluoroalkanes.

5 **[0077]** 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.

10 **[0078]** 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 fluorescence of the dye under an ultra-violet light. Solubilizing agents may be needed due to poor solubility of such UV dyes in some compositions.

15 **[0079]** 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.

20 **[0080]** 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.

25 **[0081]** 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.

30 **[0082]** Hydrocarbon ether solubilizing agents of the present invention comprise ethers containing only carbon, hydrogen and oxygen, such as dimethyl ether (DME).

[0083] 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.

35 **[0084]** 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.

40 **[0085]** 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.

45 **[0086]** 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.

50 **[0087]** 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.

55 **[0088]** 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.

5 **[0089]** 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.

10 **[0090]** 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.

15 **[0091]** 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 W 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".
20 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.

25 **[0092]** 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.

30 **[0093]** 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
35 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.

40 **[0094]** 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.

45 **[0095]** 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.

[0096] 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.

50 **[0097]** 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.

[0098] 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.

55 **[0099]** 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.

5 **[0100]** 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.

[0101] 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
10 or condense). Alternatively, evaporative cooling processes may utilize heat transfer fluids as well.

[0102] 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
15 capable of absorbing heat. A vapor compression refrigeration system is one example of such a heat sink.

[0103] 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
20 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. may be used or adapted for use in accordance with the foam embodiments of the present invention.

25 **[0104]** 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.

[0105] 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
30 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.

35 **[0106]** 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.

[0107] 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
40 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.

[0108] 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
45 discharge system; and discharging the agent into the area to prevent a fire or explosion from occurring.

50 **[0109]** 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
55 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

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agent toward a fire from one or more filed 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.

[0110] 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.

[0111] 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.

[0112] 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.

EXAMPLES

EXAMPLE 1

Impact of vapor leakage

[0113] 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		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%

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(continued)

	HFC-1234yf/HFC-125.					
	52/48	37.1	256	33.3	229	10.3%
5						
	HFC-1234yf/HFC-134					
	1/99	11.7	81	11.6	80	0.7%
	10/90	12.8	88	12.2	84	4.5%
10	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%
15	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%
20	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%
25	10/90	16.4	113	16.1	111	1.5%
	1/99	15.6	107	15.6	107	0.3%
	HFC-1234yf/HFC-152a					
30	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%
35	10/90	15.1	104	14.9	103	1.5%
	1/99	14.6	100	14.5	100	0.2%
	HFC-1234yf/HFC-161					
40	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%
45	80/20	19.8	137	19.5	134	1.9%
	90/10	18.8	129	18.6	128	0.0%
	99/1	17.9	123	17.9	123	0.1%
	HFC-1234yf/FC-143a					
50	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%
55	60/40	36.3	250	32.8	226	9.5%
	61/39	36.1	249	32.4	223	10.2%

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(continued)

	HFC-1234yf/HFC-227ea					
	84.6/15.4	18.0	124	18.0	124	0.0%
5	90/10	18.0	24	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%
10	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%
15	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-1243zf					
20	1/99	13.1	90	13.0	90	0.2%
	10/90	13.7	94	13.5	93	1.6%
	20/80	14.3	99	14.0	97	2.4%
	40/60	15.5	107	15.1	104	2.2%
25	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%
30	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%
35	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%
40	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%
45	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%
50	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%
55	60/40	17.9	123	16.0	110	10.3%
	61/39	17.9	123	16.2	112	9.4%

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(continued)

	HFC-1234yf/DME					
	53.5/46.5	13.1	90	13.1	90	0.0%
5	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%
10	90/10	15.8	109	15.3	105	3.5%
	99/1	17.6	121	17.5	121	0.6%
	HFC-1234yf/CF ₃ SCF ₃					
15	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%
20	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%
25	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)					
30	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%
35	15/45/40	213.2	1470	201.3	1388	5.6%
	10/60/30	213.0	1469	206.0	1420	3.3%
	HFC-1225ye/HFC-1234yf/HFC-134a (25 °C)					
40	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)					
45	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%
50	75/24/1	85.3	588	82.3	567	3.5%
	25/74/1	98.0	676	95.1	656	3.0%

55 **[0114]** The difference in vapor pressure between the original composition and the composition remaining after 50 weight percent is removed is less than 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

5 **[0115]** 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.

10	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%

15 Note that the superheat is included in cooling capacity calculations.

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TABLE 10

Composition (wt%)	Evap Pres (P _{sia})	Evap Pres (kPa)	Cond Pres (P _{sia})	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-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
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/ FC-125 (25/74/1)	50.2	346	202	1395	144	62.2	198	3.47	4.33
HFC-1225ye/HFC-1234yf/HFC-32 (49/49/2)	49.5	341	202.5	1396	146.9	63.8	201	3.52	4.4

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[0116] 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

[0117] 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	155.6°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	<u>wt%</u>					
HFC-125/HFC-1234yf/isobutane	87.1/11.5/1.4	343	2186	93.3	1758	4.52
HFC-125/HFC-1234yf/n-butane	87.1/11.5/1.4	340	2173	93.4	1748	4.53
HFC-32/CF ₃ I/HFC-1234yf	5/50/45	199	1377	107	1254	5.11
HFC-32/CF ₃ I/HFC-1234yf	5/30/65	197	1382	103	1241	5.11
HFC-32/CF ₃ I/HFC-1234yf	10/25/65	220	1542	107	1374	5.04
HFC-32/CF ₃ I/HFC-1234yf	20/10/70	255	1786	114	1577	4.95
HFC-32/CF ₃ I/HFC-1234yf	30/10/60	295	2020	123	1795	4.88
HFC-32/CF ₃ I/HFC-1234yf	30/20/50	305	2057	125	1843	4.85
HFC-32/CF ₃ I/HFC-1234yf	30/30/40	314	2091	128	1887	4.85
HFC-32/CF ₃ I/HFC-1234yf	20/40/40	275	1861	121	1679	4.92
HFC-32/CF ₃ I/HFC-1234yf	10/40/50	225	1558	111	1404	5.04
HFC-32/CF ₃ I/HFC-1234yf	50/20/30	378	2447	143	2238	4.73
HFC-32/CF ₃ I/HFC-1234yf	40/30/30	354	2305	137	2099	4.76
HFC-32/CF ₃ I/HFC-1234yf	40/40/20	360	2336	142	2136	4.74
HFC-32/CF ₃ I/HFC-1234yf	35/35/30	338	2217	135	2015	4.78
HFC-32/CF ₃ I/HFC-1234yf	35/30/35	334	2202	133	1996	4.80
HFC-32/CF ₃ I/HFC-1234yf	50/25/25	384	2468	145	2267	4.72
HFC-32/CF ₃ I/HFC-1225ye/HFC-1234yf	40/20/20/20	331	2246	136	1999	4.76
HFC-32/CF ₃ I/HFC-1225ye/HFC-1234yf	30/20/25/25	290	2029	127	1782	4.83
HFC-32/CF ₃ I/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

(continued)

Candidate Replacement	wt%					
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-125/HFC-1234yf/HFC-1225ye	30/30/20/20	328	2251	122	1925	4.71
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/	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 ₃ I/HFC-1234yf/HFC-1225ye	30/25/5/35/5	335	2240	121	1954	4.76
HFC-32/HFC-125/CF ₃ I/HFC-1234yf	30/25/5/40	338	2245	121	1966	4.76
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 ₃ I/HFC-1234yf	25/25/10/40	323	2154	118	1884	4.78

[0118] 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

[0119] 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-1234yf	40/50/10	868	3185	84.4	4496	13.06

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(continued)

Candidate Replacement	wt%					
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-1234yf/n-butane	67/32/1	623	2344	66.1	3043	12.85
HFC-125/HFC-1234yf/isobutane	67/32/1	626	2352	66.3	3051	12.83

[0120] 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

[0121] 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-134a/HFC-1234yf/CF ₃ I (30/20/5/45)	611	1845	89.6	4107	9.66
HFC-32/HFC-134a/HFC-1234yf/GF ₃ I (25/20/10/45)	575	1745	86.5	3891	9.76
HFC-32/HFC-134a/HFC-1234yf/CF ₃ I (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.

Claims

1. A composition comprising 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 and CF_3SCF_3 ;
 or a composition selected from the group consisting of HFC-1234yf, dimethylether and CF_3I ; HFC-1234yf, HFC-32 and CF_3I ; HFC-1234yf, HFC-32, HFC-125 and CF_3I ; and HFC-1234yf, HFC-32, HFC-134a and CF_3I .

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

HFC-1234yf and HFC-134a; HFC-1234yf and HFC-152a; HFC-1234yf and HFC-32; HFC-1234yf, HFC-125 and n-butane; HFC-1234yf, HFC-32 and HFC-125; HFC-1234yf, HFC-125 and isobutane; HFC-1234yf, HFC-32 and HFC-143a; HFC-1234yf, HFC-32 and isobutane; HFC-1234yf, HFC-125 and HFC-143a; HFC-1234yf, HFC-125 and isobutane; HFC-1234yf, HFC-134 and propane; HFC-1234yf, HFC-134 and dimethylether; HFC-1234yf, HFC-134a and propane; HFC-1234yf, HFC-134a and n-butane; HFC-1234yf, HFC-134a and isobutane; HFC-1234yf, HFC-134a and dimethylether; HFC-1234yf, HFC-143a and propane; HFC-1234yf, HFC-143a and dimethylether; HFC-1234yf, HFC-152a and n-butane; HFC-1234yf, HFC-152a and isobutane; HFC-1234yf, HFC-152a and dimethylether; HFC-1234yf, HFC-227ea and propane; HFC-1234yf, HFC-227ea and n-butane; HFC-1234yf, HFC-227ea and isobutane; HFC-1234yf, HFC-227ea and dimethylether; HFC-1234yf, n-butane and dimethylether; HFC-1234yf, isobutane and dimethylether; HFC-1234yf, dimethylether and CF_3SCF_3 ; and HFC-1234yf, HFC-32 and HFC-125.

3. A composition of claim 1 selected from the group consisting of:

about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent HFC-134a; about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent HFC-32; about 1 weight percent to about 99 weight percent HFC-1234y and about 99 weight percent to about 1 weight percent HFC-152a; about 0.1 weight percent to about 98 weight percent HFC-32, about 0.1 weight percent to about 98 weight percent HFC-125, and about 0.1 weight percent to about 98 weight percent HFC-1234yf; about 0.1 weight percent to about 98 weight percent HFC-125, about 0.1 weight percent to about 98 weight percent HFC-1234yf, and about 0.1 weight percent to about 98 weight percent n-butane; and about 0.1 weight percent to about 98 weight percent HFC-125, about 0.1 weight percent to about 98 weight percent HFC-1234yf, and about 0.1 weight percent to about 98 weight percent isobutane; about 1 weight percent to about 50 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-32 and about 1 weight percent to about 98 weight percent HFC-143a; about 1 weight percent to about 40 weight percent HFC-1234yf, about 59 weight percent to about 98 weight percent HFC-32 and about 1 weight percent to about 30 weight percent isobutane; about 1 weight percent to about 60 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-125 and about 1 weight percent to about 98 weight percent HFC-143a; about 1 weight percent to about 40 weight percent HFC-1234yf, about 59 weight percent to about 98 weight percent HFC-125 and about 1 weight percent to about 20 weight percent isobutane; about 1 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 70 weight percent HFC-134 and about 19 weight percent to about 90 weight percent propane; about 1 weight percent to about 70 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-134 and about 29 weight percent to about 98 weight percent dimethylether; about 1 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 80 weight percent HFC-134a and about 19 weight percent to about 98 weight percent propane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-134a and about 1 weight percent to about 30 weight percent n-butane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-134a and about 1 weight percent to about 30 weight percent isobutane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-134a and about 1 weight percent to about 80 weight percent dimethylether; about 1 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-143a and about 1 weight percent to about 98 weight percent propane; about 1 weight percent to about 40 weight percent HFC-1234yf, about 59 weight percent to about 98 weight percent HFC-143a and about 1 weight percent to about 20 weight percent dimethylether; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-152a and about 1 weight percent to about 30 weight percent n-butane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 90 weight percent HFC-152a

percent to about 80 weight percent HFC-152a and about 1 weight percent to about 20 weight percent isobutane; about 10 weight percent to about 70 weight percent HFC-1234yf, about 10 weight percent to about 80 weight percent HFC-152a and about 1 weight percent to about 20 weight percent dimethylether; about 10 weight percent to about 60 weight percent HFC-1234yf, about 10 weight percent to about 60 weight percent HFC-227ea and about 29 weight percent to about 50 weight percent propane; about 50 weight percent to about 98 weight percent HFC-1234yf, about 10 weight percent to about 49 weight percent HFC-227ea and about 1 weight percent to about 10 weight percent n-butane; about 50 weight percent to about 98 weight percent HFC-1234yf, about 10 weight percent to about 49 weight percent HFC-227ea and about 1 weight percent to about 10 weight percent isobutane; about 10 weight percent to about 80 weight percent HFC-1234yf, about 10 weight percent to about 80 weight percent HFC-227ea and about 1 weight percent to about 20 weight percent dimethylether; about 10 weight percent to about 80 weight percent HFC-1234yf, about 10 weight percent to about 40 weight percent n-butane and about 1 weight percent to about 20 weight percent dimethylether; about 10 weight percent to about 90 weight percent HFC-1234yf, about 1 weight percent to about 40 weight percent isobutane and about 1 weight percent to about 20 weight percent dimethylether; about 10 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 20 weight percent dimethylether and about 10 weight percent to about 80 weight percent CF₃I; about 10 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 20 weight percent dimethylether and about 10 weight percent to about 70 weight percent CF₃SCF₃; about 10 weight percent to about 80 weight percent HFC-1234yf, about 10 weight percent to about 80 weight percent HFC-32 and about 10 weight percent to about 80 weight percent HFC-125; about 10 weight percent to about 80 weight percent HFC-1234yf, about 5 weight percent to about 70 weight percent HFC-32 and about 10 weight percent to about 80 weight percent HFC-125 and about 5 weight percent to about 80 weight percent CF₃I; about 1 weight percent to about 70 weight percent HFC-1234yf, about 5 weight percent to about 70 weight percent HFC-32 and about 5 weight percent to about 80 weight percent HFC-134a and about 5 weight percent to about 70 weight percent CF₃I; and about 10 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 70 weight percent HFC-32 and about 1 weight percent to about 80 weight percent CF₃I.

5. A composition of claim 1 selected from the group consisting of: about 90 weight percent HFC-1234yf and about 10 weight percent HFC-134a; about 95 weight percent HFC-1234yf and about 5 weight percent HFC-32; about 80 weight percent HFC-1234yf and about 20 weight percent HFC-152a about 40 weight percent HFC-32, about 50 weight percent HFC-125, and about 10 weight percent HFC-1234yf; about 23 weight percent HFC-32, about 25 weight percent HFC-125, and about 52 weight percent HFC-1234yf; about 15 weight percent HFC-32, about 45 weight percent HFC-125, and about 40 weight percent HFC-1234yf; about 10 weight percent HFC-32, about 60 weight percent HFC-125, and about 30 weight percent HFC-1234yf; about 67 weight percent HFC-125, about 32 weight percent HFC-1234yf, and about 1 weight percent n-butane; and about 87.1 weight percent HFC-125, about 11.5 weight percent HFC-1234yf, and about 1.4 weight percent isobutane.
6. A composition of claim 1 comprising an azeotropic or near-azeotropic composition selected from the group consisting of: about 1 weight percent to about 57 weight percent HFC-1234yf and about 99 weight percent to about 43 weight percent HFC-32; about 1 weight percent to about 51 weight percent HFC-1234yf and about 99 weight percent to about 49 weight percent HFC-125; about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent HFC-134; about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent HFC-134a; about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent HFC-152a; about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent HFC-161; about 1 weight percent to about 60 weight percent HFC-1234yf and about 40 weight percent to about 1 weight percent HFC-143a; about 29 weight percent to about 99 weight percent HFC-1234yf and about 71 weight percent to about 1 weight percent HFC-227ea; about 66 weight percent to about 99 weight percent HFC-1234yf and about 34 weight percent to about 1 weight percent HFC-236fa; about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent HFC-1243zf; about 1 weight percent to about 80 weight percent HFC-1234yf and about 99 weight percent to about 20 weight percent propane; about 71 weight percent to about 99 weight percent HFC-1234yf and about 29 weight percent to about 1 weight percent n-butane; about 60 weight percent to about 99 weight percent HFC-1234yf and about 40 weight percent to about 1 weight percent isobutane; about 1 weight percent to about 99 weight percent HFC-1234yf and about 99 weight percent to about 1 weight percent dimethylether; about 80 weight percent to about 98 weight percent HFC-125, about 1 weight percent to about 19 weight percent HFC-1234yf, and about 1 weight percent to about 10 weight percent isobutane; about 80 weight percent to about 98 weight percent HFC-125, about 1 weight percent to about 19 weight percent HFC-1234yf, and about 1 weight percent to about 10 weight percent n-butane; 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 55 weight percent HFC-1234yf;

about 1 weight percent to about 50 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-32 and about 1 weight percent to about 98 weight percent HFC-143a; about 1 weight percent to about 40 weight percent HFC-1234yf, about 59 weight percent to about 98 weight percent HFC-32 and about 1 weight percent to about 30 weight percent isobutane; about 1 weight percent to about 60 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-125 and about 1 weight percent to about 98 weight percent HFC-143a; about 1 weight percent to about 40 weight percent HFC-1234yf, about 59 weight percent to about 98 weight percent HFC-125 and about 1 weight percent to about 20 weight percent isobutane; about 1 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 70 weight percent HFC-134 and about 19 weight percent to about 90 weight percent propane; about 1 weight percent to about 70 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-134 and about 29 weight percent to about 98 weight percent dimethylether; about 1 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 80 weight percent HFC-134a and about 19 weight percent to about 98 weight percent propane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-134a and about 1 weight percent to about 30 weight percent n- butane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-134a and about 1 weight percent to about 40 weight percent dimethylether; about 1 weight percent to about 80 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-143a and about 1 weight percent to about 98 weight percent propane; about 1 weight percent to about 40 weight percent HFC-1234yf, about 59 weight percent to about 98 weight percent HFC-143a and about 1 weight percent to about 20 weight percent dimethylether; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent HFC-152a and about 1 weight percent to about 30 weight percent n- butane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 90 weight percent HFC-152a and about 1 weight percent to about 40 weight percent isobutane; about 1 weight percent to about 70 weight percent HFC-1234yf, 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 80 weight percent HFC-1234yf, about 1 weight percent to about 70 weight percent HFC-227ea and about 29 weight percent to about 98 weight percent propane; about 40 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 59 weight percent HFC-227ea and about 1 weight percent to about 20 weight percent n-butane; about 30 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 69 weight percent HFC-227ea and about 1 weight percent to about 30 weight percent isobutane; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 80 weight percent HFC-227ea and about 1 weight percent to about 98 weight percent dimethylether; about 1 weight percent to about 98 weight percent HFC-1234yf, 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 HFC-1234yf, about 1 weight percent to about 50 weight percent isobutane and about 1 weight percent to about 98 weight percent dimethylether; about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 98 weight percent dimethylether and about 1 weight percent to about 98 weight percent CF₃I; and about 1 weight percent to about 98 weight percent HFC-1234yf, about 1 weight percent to about 40 weight percent dimethylether and about 1 weight percent to about 98 weight percent CF₃SCF₃.

7. The composition of claim 1 comprising an azeotropic composition selected from the group consisting of:

7.4 weight percent HFC-1234yf and 92.6 weight percent HFC-32 having a vapor pressure of about 49.2 psia (339 kPa) at a temperature of about -25 °C;

10.9 weight percent HFC-1234yf and 89.1 weight percent HFC-125 having a vapor pressure of about 40.7 psia (281 kPa) at a temperature of about -25 °C;

70.4 weight percent HFC-1234yf and 29.6 weight percent HFC-134a having a vapor pressure of about 18.4 psia (127 kPa) at a temperature of about -25 °C;

91.0 weight percent HFC-1234yf and 9.0 weight percent HFC-152a having a vapor pressure of about 17.9 psia (123 kPa) at a temperature of about -25 °C;

17.3 weight percent HFC-1234yf and 82.7 weight percent HFC-143a having a vapor pressure of about 29.5 psia (272 kPa) at a temperature of about -25 °C;

84.6 weight percent HFC-1234yf and 15.4 weight percent HFC-227ea having a vapor pressure of about 18.0 psia (124 kPa) at a temperature of about -25 °C;

51.5 weight percent HFC-1234yf and 48.5 weight percent propane having a vapor pressure of about 33.5 psia (231 kPa) at a temperature of about -25 °C;

98.1 weight percent HFC-1234yf and 1.9 weight percent n- butane having a vapor pressure of about 17.9 psia

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(123 kPa) at a temperature of about -25 °C;

88.1 weight percent HFC-1234yf and 11.9 weight percent isobutane having a vapor pressure of about 19.0 psia (131 kPa) at a temperature of about -25 °C;

53.5 weight percent HFC-1234yf and 46.5 weight percent dimethylether having a vapor pressure of about 13.1 psia (90 kPa) at a temperature of about -25 °C;

89.1 weight percent HFC-125, 9.7 weight percent HFC-1234yf and 1.2 weight percent isobutane having a vapor pressure of about 40.8 psia (281 kPa) at a temperature of about -25 °C;

3.9 weight percent HFC-1234yf, 74.3 weight percent HFC-32, and 21.8 weight percent HFC-143a having a vapor pressure of about 50.0 psia (345 kPa) at a temperature of about -25 °C;

1.1 weight percent HFC-1234yf, 92.1 weight percent HFC-32 and 6.8 weight percent isobutane having a vapor pressure of about 50.0 psia (345 kPa) at a temperature of about -25 °C;

14.4 weight percent HFC-1234yf, 43.5 weight percent HFC-125 and 42.1 weight percent HFC-143a having a vapor pressure of about 38.6 psia (266 kPa) at a temperature of about -25 °C;

4.3 weight percent HFC-1234yf, 39.1 weight percent HFC-134 and 56.7 weight percent propane having a vapor pressure of about 34.3 psia (236 kPa) at a temperature of about -25 °C;

15.2 weight percent HFC-1234yf, 67.0 weight percent HFC-134 and 17.8 weight percent dimethylether having a vapor pressure of about 10.4 psia (71.6 kPa) at a temperature of about -25 °C;

24.5 weight percent HFC-1234yf, 31.1 weight percent HFC-134a and 44.5 weight percent propane having a vapor pressure of about 34.0 psia (234 kPa) at a temperature of about -25 °C;

60.3 weight percent HFC-1234yf, 35.2 weight percent HFC-134a and 4.5 weight percent n-butane having a vapor pressure of about 18.6 psia (128 kPa) at a temperature of about -25 °C;

48.6 weight percent HFC-1234yf, 37.2 weight percent HFC-134a and 14.3 weight percent isobutane having a vapor pressure of about 19.9 psia (137 kPa) at a temperature of about -25 °C;

24.0 weight percent HFC-1234yf, 67.9 weight percent HFC-134a and 8.1 weight percent dimethylether having a vapor pressure of about 17.2 psia (119 kPa) at a temperature of about -25 °C;

17.7 weight percent HFC-1234yf, 71.0 weight percent HFC-143a and 11.3 weight percent propane having a vapor pressure of about 40.4 psia (279 kPa) at a temperature of about -25 °C;

5.7 weight percent HFC-1234yf, 93.0 weight percent HFC-143a and 1.3 weight percent dimethylether having a vapor pressure of about 39.1 psia (269 kPa) at a temperature of about -25 °C;

86.6 weight percent HFC-1234yf, 10.8 weight percent HFC-152a and 2.7 weight percent n-butane having a vapor pressure of about 18.0 psia (124 kPa) at a temperature of about -25 °C;

75.3 weight percent HFC-1234yf, 11.8 weight percent HFC-152a and 12.9 weight percent isobutane having a vapor pressure of about 19.1 psia (132 kPa) at a temperature of about -25 °C;

24.6 weight percent HFC-1234yf, 43.3 weight percent HFC-152a and 32.1 weight percent dimethylether having a vapor pressure of about 11.8 psia (81.2 kPa) at a temperature of about -25 °C;

35.6 weight percent HFC-1234yf, 17.8 weight percent HFC-227ea and 46.7 weight percent propane having a vapor pressure of about 33.8 psia (233 kPa) at a temperature of about -25 °C;

81.9 weight percent HFC-1234yf, 16.0 weight percent HFC-227ea and 2.1 weight percent n-butane having a vapor pressure of about 18.1 psia (125 kPa) at a temperature of about -25 °C;

86.6 weight percent HFC-1234yf, 10.8 weight percent HFC-152a and 2.7 weight percent n-butane having a vapor pressure of about 18.0 psia (124 kPa) at a temperature of about -25 °C;

70.2 weight percent HFC-1234yf, 18.2 weight percent HFC-227ea and 11.6 weight percent isobutane having a vapor pressure of about 19.3 psia (133 kPa) at a temperature of about -25 °C;

28.3 weight percent HFC-1234yf, 55.6 weight percent HFC-227ea and 16.1 weight percent dimethylether having a vapor pressure of about 15.0 psia (104 kPa) at a temperature of about -25 °C;

48.9 weight percent HFC-1234yf, 4.6 weight percent n-butane and 46.4 weight percent dimethylether having a vapor pressure of about 13.2 psia (90.7 kPa) at a temperature of about -25 °C;

31.2 weight percent HFC-1234yf, 26.2 weight percent isobutane and 42.6 weight percent dimethylether having a vapor pressure of about 14.2 psia (97.8 kPa) at a temperature of about -25 °C;

16.3 weight percent HFC-1234yf, 10.0 weight percent dimethylether and 73.7 weight percent CF₃I having a vapor pressure of about 15.7 psia (108 kPa) at a temperature of about -25 °C; and

34.3 weight percent HFC-1234yf, 10.5 weight percent dimethylether and 55.2 weight percent CF₃SCF₃ having a vapor pressure of about 14.6 psia (100 kPa) at a temperature of about -25 °C,

8. The composition as in any of claims 1-7, further comprising a lubricant selected from the group consisting of polyol esters, polyalkylene glycols, polyvinyl ethers, mineral oil, alkylbenzenes, synthetic paraffins, synthetic naphthenes, and poly(alpha)olefins.

9. The composition as in any of claims 1-7, 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 (N₂O) and combinations thereof.
- 5 10. The composition any of claims 1-7, 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.
- 10 11. A method for detecting the composition of claim 10 in a compression refrigeration, air conditioning, or heat pump apparatus, said method comprising providing said composition to said apparatus, and providing a suitable means for detecting said composition at a leak point or in the vicinity of said apparatus.
12. A method of producing cooling, said method comprising: evaporating a composition of any of claims 1-7 in the vicinity of a body to be cooled and thereafter condensing said composition.
- 15 13. A method of producing heating, said method comprising: condensing a composition of any of claims 1-7 in the vicinity of a body to be heated and thereafter evaporating said composition.
- 20 14. 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, R123, R11, R245fa, R114, R236fa, R124, R12, R410A, R407C, R417A, R422A, R507A, R502, and R404A, said method comprising providing the composition of any of claims 1-7 to said refrigeration, air-conditioning, or heat pump apparatus that uses, used or is designed to use said high GWP refrigerant.
- 25 15. A refrigeration, air-conditioning, or heat pump apparatus containing a composition as claimed in any one of claims 1-7.

Patentansprüche

- 30 1. Zusammensetzung, umfassend HFC-1234yf und mindestens eine Verbindung, ausgewählt aus der Gruppe, bestehend aus: 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, Propan, n-Butan, Isobutan, 2-Methylbutan, n-Pentan, Cyclopentan, Dimethylether und CF₃SCF₃;
 oder eine Zusammensetzung, ausgewählt aus der Gruppe, bestehend aus HFC-1234yf, Dimethylether und CF₃I;
 35 HFC-1234yf, HFC-32 und CF₃I; HFC-1234yf, HFC-32, HFC-125 und CF₃I; und HFC-1234yf, HFC-32, HFC-134a und CF₃I.
- 40 2. Zusammensetzung nach Anspruch 1, ausgewählt aus der Gruppe, bestehend aus: HFC-1234yf und HFC-134a; HFC-1234yf und HFC-152a; HFC-1234yf und HFC-32; HFC-1234yf, HFC-125 und n-Butan; HFC-1234yf, HFC-32 und HFC-125; HFC-1234yf, HFC-125 und Isobutan; HFC-1234yf, HFC-32 und HFC-143a; HFC-1234yf, HFC-32 und Isobutan; HFC-1234yf, HFC-125 und HFC-143a; HFC-1234yf, HFC-125 und Isobutan; HFC-1234yf, HFC-134 und Propan; HFC-1234yf, HFC-134 und Dimethylether; HFC-1234yf, HFC-134a und Propan; HFC-1234yf, HFC-134a und n-Butan; HFC-1234yf, HFC-134a und Isobutan; HFC-1234yf, HFC-134a und Dimethylether; HFC-1234yf, HFC-143a und Propan; HFC-1234yf, HFC-143a und Dimethylether; HFC-1234yf, HFC-152a und n-Butan; HFC-1234yf, HFC-152a und Isobutan; HFC-1234yf, HFC-152a und Dimethylether; HFC-1234yf, HFC-227ea und Propan; HFC-1234yf, HFC-227ea und n-Butan; HFC-1234yf, HFC-227ea und Isobutan; HFC-1234yf, HFC-227ea und Dimethylether; HFC-1234yf, n-Butan und Dimethylether; HFC-1234yf, Isobutan und Dimethylether; HFC-1234yf, Dimethylether und CF₃SCF₃; und HFC-1234yf, HFC-32 und HFC-125.
- 45 3. Zusammensetzung nach Anspruch 1, ausgewählt aus der Gruppe, bestehend aus:
 etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-134a; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-32; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-152a; etwa 0,1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-32, etwa 0,1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-125 und etwa 0,1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf; etwa 0,1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-125, etwa 0,1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf und etwa 0,1

5. Zusammensetzung nach Anspruch 1, ausgewählt aus der Gruppe, bestehend aus: etwa 90 Gewichtsprozent HFC-1234yf und etwa 10 Gewichtsprozent HFC-134a; etwa 95 Gewichtsprozent HFC-1234yf und etwa 5 Gewichtsprozent HFC-32; etwa 80 Gewichtsprozent HFC-1234yf und etwa 20 Gewichtsprozent HFC-152a; etwa 40 Gewichtsprozent HFC-32, etwa 50 Gewichtsprozent HFC-125 und etwa 10 Gewichtsprozent HFC-1234yf; etwa 23 Gewichtsprozent HFC-32, etwa 25 Gewichtsprozent HFC-125 und etwa 52 Gewichtsprozent HFC-1234yf; etwa 15 Gewichtsprozent HFC-32, etwa 45 Gewichtsprozent HFC-125 und etwa 40 Gewichtsprozent HFC-1234yf; etwa 10 Gewichtsprozent HFC-32, etwa 60 Gewichtsprozent HFC-125 und etwa 30 Gewichtsprozent HFC-1234yf; etwa 67 Gewichtsprozent HFC-125, etwa 32 Gewichtsprozent HFC-1234yf und etwa 1 Gewichtsprozent n-Butan; und etwa 87,1 Gewichtsprozent HFC-125, etwa 11,5 Gewichtsprozent HFC-1234yf und etwa 1,4 Gewichtsprozent Isobutan.
6. Zusammensetzung nach Anspruch 1, umfassend eine azeotrope oder nahezu azeotrope Zusammensetzung, ausgewählt aus der Gruppe, bestehend aus: etwa 1 Gewichtsprozent bis etwa 57 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 43 Gewichtsprozent HFC-32; etwa 1 Gewichtsprozent bis etwa 51 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 49 Gewichtsprozent HFC-125; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-134; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-134a; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-152a; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-161; etwa 1 Gewichtsprozent bis etwa 60 Gewichtsprozent HFC-1234yf und etwa 40 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-143a; etwa 29 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 71 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-227ea; etwa 66 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 34 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-236fa; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent HFC-1243zf; etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 20 Gewichtsprozent Propan; etwa 71 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 29 Gewichtsprozent bis etwa 1 Gewichtsprozent n-Butan; etwa 60 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 40 Gewichtsprozent bis etwa 1 Gewichtsprozent Isobutan; etwa 1 Gewichtsprozent bis etwa 99 Gewichtsprozent HFC-1234yf und etwa 99 Gewichtsprozent bis etwa 1 Gewichtsprozent Dimethylether; etwa 80 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-125, etwa 1 Gewichtsprozent bis etwa 19 Gewichtsprozent HFC-1234yf und etwa 1 Gewichtsprozent bis etwa 10 Gewichtsprozent Isobutan; etwa 80 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-125, etwa 1 Gewichtsprozent bis etwa 19 Gewichtsprozent HFC-1234yf und etwa 1 Gewichtsprozent bis etwa 10 Gewichtsprozent n-Butan; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-32, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-125 und etwa 1 Gewichtsprozent bis etwa 55 Gewichtsprozent HFC-1234yf; etwa 1 Gewichtsprozent bis etwa 50 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-32 und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-143a; etwa 1 Gewichtsprozent bis etwa 40 Gewichtsprozent HFC-1234yf, etwa 59 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-32 und etwa 1 Gewichtsprozent bis etwa 30 Gewichtsprozent Isobutan; etwa 1 Gewichtsprozent bis etwa 60 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-125 und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-143a; etwa 1 Gewichtsprozent bis etwa 40 Gewichtsprozent HFC-1234yf, etwa 59 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-125 und etwa 1 Gewichtsprozent bis etwa 20 Gewichtsprozent Isobutan; etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 70 Gewichtsprozent HFC-134 und etwa 19 Gewichtsprozent bis etwa 90 Gewichtsprozent Propan; etwa 1 Gewichtsprozent bis etwa 70 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-134 und etwa 29 Gewichtsprozent bis etwa 98 Gewichtsprozent Dimethylether; etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent HFC-134a und etwa 19 Gewichtsprozent bis etwa 98 Gewichtsprozent Propan; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-134a und etwa 1 Gewichtsprozent bis etwa 30 Gewichtsprozent n-Butan; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-134a und etwa 1 Gewichtsprozent bis etwa 30 Gewichtsprozent Isobutan; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-134a und etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent Dimethylether; etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-143a und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent Propan; etwa 1 Gewichtsprozent bis etwa 40 Gewichtsprozent HFC-1234yf, etwa 59 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-143a und etwa 1 Gewichtsprozent bis etwa 20 Gewichtsprozent Dimethylether; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-152a und etwa 1 Gewichtsprozent bis etwa 30 Gewichtsprozent n-Butan; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 90 Gewichtsprozent HFC-152a und etwa

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1 Gewichtsprozent bis etwa 40 Gewichtsprozent Isobutan; etwa 1 Gewichtsprozent bis etwa 70 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-152a und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent Dimethylether; etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 70 Gewichtsprozent HFC-227ea und etwa 29 Gewichtsprozent bis etwa 98 Gewichtsprozent Propan; etwa 40 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 59 Gewichtsprozent HFC-227ea und etwa 1 Gewichtsprozent bis etwa 20 Gewichtsprozent n-Butan; etwa 30 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 69 Gewichtsprozent HFC-227ea und etwa 1 Gewichtsprozent bis etwa 30 Gewichtsprozent Isobutan; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 80 Gewichtsprozent HFC-227ea und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent Dimethylether; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 40 Gewichtsprozent n-Butan und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent Dimethylether; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 50 Gewichtsprozent Isobutan und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent Dimethylether; etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent Dimethylether und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent CF₃I; und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent HFC-1234yf, etwa 1 Gewichtsprozent bis etwa 40 Gewichtsprozent Dimethylether und etwa 1 Gewichtsprozent bis etwa 98 Gewichtsprozent CF₃SCF₃.

7. Zusammensetzung nach Anspruch 1, umfassend eine azeotrope Zusammensetzung, ausgewählt aus der Gruppe, bestehend aus:

7,4 Gewichtsprozent HFC-1234yf und 92,6 Gewichtsprozent HFC-32 mit einem Dampfdruck von etwa 49,2 psia (339 kPa) bei einer Temperatur von etwa -25°C;

10,9 Gewichtsprozent HFC-1234yf und 89,1 Gewichtsprozent HFC-125 mit einem Dampfdruck von etwa 40,7 psia (281 kPa) bei einer Temperatur von etwa -25°C;

70,4 Gewichtsprozent HFC-1234yf und 29,6 Gewichtsprozent HFC-134a mit einem Dampfdruck von etwa 18,4 psia (127 kPa) bei einer Temperatur von etwa -25°C;

91,0 Gewichtsprozent HFC-1234yf und 9,0 Gewichtsprozent HFC-152a mit einem Dampfdruck von etwa 17,9 psia (123 kPa) bei einer Temperatur von etwa -25°C;

17,3 Gewichtsprozent HFC-1234yf und 82,7 Gewichtsprozent HFC-143a mit einem Dampfdruck von etwa 29,5 psia (272 kPa) bei einer Temperatur von etwa -25°C;

84,6 Gewichtsprozent HFC-1234yf und 15,4 Gewichtsprozent HFC-227ea mit einem Dampfdruck von etwa 18,0 psia (124 kPa) bei einer Temperatur von etwa -25°C;

51,5 Gewichtsprozent HFC-1234yf und 48,5 Gewichtsprozent Propan mit einem Dampfdruck von etwa 33,5 psia (231 kPa) bei einer Temperatur von etwa -25°C;

98,1 Gewichtsprozent HFC-1234yf und 1,9 Gewichtsprozent n-Butan mit einem Dampfdruck von etwa 17,9 psia (123 kPa) bei einer Temperatur von etwa -25°C;

88,1 Gewichtsprozent HFC-1234yf und 11,9 Gewichtsprozent Isobutan mit einem Dampfdruck von etwa 19,0 psia (131 kPa) bei einer Temperatur von etwa -25°C;

53,5 Gewichtsprozent HFC-1234yf und 46,5 Gewichtsprozent Dimethylether mit einem Dampfdruck von etwa 13,1 psia (90 kPa) bei einer Temperatur von etwa -25°C;

89,1 Gewichtsprozent HFC-125, 9,7 Gewichtsprozent HFC-1234yf und 1,2 Gewichtsprozent Isobutan mit einem Dampfdruck von etwa 40,8 psia (281 kPa) bei einer Temperatur von etwa -25°C;

3,9 Gewichtsprozent HFC-1234yf, 74,3 Gewichtsprozent HFC-32 und 21,8 Gewichtsprozent HFC-143a mit einem Dampfdruck von etwa 50,0 psia (345 kPa) bei einer Temperatur von etwa -25°C;

1,1 Gewichtsprozent HFC-1234yf, 92,1 Gewichtsprozent HFC-32 und 6,8 Gewichtsprozent Isobutan mit einem Dampfdruck von etwa 50,0 psia (345 kPa) bei einer Temperatur von etwa -25°C;

14,4 Gewichtsprozent HFC-1234yf, 43,5 Gewichtsprozent HFC-125 und 42,1 Gewichtsprozent HFC-143a mit einem Dampfdruck von etwa 38,6 psia (266 kPa) bei einer Temperatur von etwa -25°C;

4,3 Gewichtsprozent HFC-1234yf, 39,1 Gewichtsprozent HFC-134a und 56,7 Gewichtsprozent Propan mit einem Dampfdruck von etwa 34,3 psia (236 kPa) bei einer Temperatur von etwa -25°C;

15,2 Gewichtsprozent HFC-1234yf, 67,0 Gewichtsprozent HFC-134a und 17,8 Gewichtsprozent Dimethylether mit einem Dampfdruck von etwa 10,4 psia (71,6 kPa) bei einer Temperatur von etwa -25°C;

24,5 Gewichtsprozent HFC-1234yf, 31,1 Gewichtsprozent HFC-134a und 44,5 Gewichtsprozent Propan mit einem Dampfdruck von etwa 34,0 psia (234 kPa) bei einer Temperatur von etwa -25°C;

60,3 Gewichtsprozent HFC-1234yf, 35,2 Gewichtsprozent HFC-134a und 4,5 Gewichtsprozent n-Butan mit einem Dampfdruck von etwa 18,6 psia (128 kPa) bei einer Temperatur von etwa -25°C;

48,6 Gewichtsprozent HFC-1234yf, 37,2 Gewichtsprozent HFC-134a und 14,3 Gewichtsprozent Isobutan mit

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einem Dampfdruck von etwa 19,9 psia (137 kPa) bei einer Temperatur von etwa -25°C;
24,0 Gewichtsprozent HFC-1234yf, 67,9 Gewichtsprozent HFC-134a und 8,1 Gewichtsprozent Dimethylether mit einem Dampfdruck von etwa 17,2 psia (119 kPa) bei einer Temperatur von etwa -25°C;
17,7 Gewichtsprozent HFC-1234yf, 71,0 Gewichtsprozent HFC-143a und 11,3 Gewichtsprozent Propan mit
5 einem Dampfdruck von etwa 40,4 psia (279 kPa) bei einer Temperatur von etwa -25°C;
5,7 Gewichtsprozent HFC-1234yf, 93,0 Gewichtsprozent HFC-143a und 1,3 Gewichtsprozent Dimethylether mit einem Dampfdruck von etwa 39,1 psia (269 kPa) bei einer Temperatur von etwa -25°C;
86,6 Gewichtsprozent HFC-1234yf, 10,8 Gewichtsprozent HFC-152a und 2,7 Gewichtsprozent n-Butan mit
10 einem Dampfdruck von etwa 18,0 psia (124 kPa) bei einer Temperatur von etwa -25°C;
75,3 Gewichtsprozent HFC-1234yf, 11,8 Gewichtsprozent HFC-152a und 12,9 Gewichtsprozent Isobutan mit einem Dampfdruck von etwa 19,1 psia (132 kPa) bei einer Temperatur von etwa -25°C;
24,6 Gewichtsprozent HFC-1234yf, 43,3 Gewichtsprozent HFC-152a und 32,1 Gewichtsprozent Dimethylether mit einem Dampfdruck von etwa 11,8 psia (81,2 kPa) bei einer Temperatur von etwa -25°C;
35,6 Gewichtsprozent HFC-1234yf, 17,8 Gewichtsprozent HFC-227ea und 46,7 Gewichtsprozent Propan mit
15 einem Dampfdruck von etwa 33,8 psia (233 kPa) bei einer Temperatur von etwa -25°C;
81,9 Gewichtsprozent HFC-1234yf, 16,0 Gewichtsprozent HFC-227ea und 2,1 Gewichtsprozent n-Butan mit einem Dampfdruck von etwa 18,1 psia (125 kPa) bei einer Temperatur von etwa -25°C;
86,6 Gewichtsprozent HFC-1234yf, 10,8 Gewichtsprozent HFC-152a und 2,7 Gewichtsprozent n-Butan mit
20 einem Dampfdruck von etwa 18,0 psia (124 kPa) bei einer Temperatur von etwa -25°C;
70,2 Gewichtsprozent HFC-1234yf, 18,2 Gewichtsprozent HFC-227ea und 11,6 Gewichtsprozent Isobutan mit einem Dampfdruck von etwa 19,3 psia (133 kPa) bei einer Temperatur von etwa -25°C;
28,3 Gewichtsprozent HFC-1234yf, 55,6 Gewichtsprozent HFC-227ea und 16,1 Gewichtsprozent Dimethylether mit einem Dampfdruck von etwa 15,0 psia (104 kPa) bei einer Temperatur von etwa -25°C;
48,9 Gewichtsprozent HFC-1234yf, 4,6 Gewichtsprozent n-Butan und 46,4 Gewichtsprozent Dimethylether mit
25 einem Dampfdruck von etwa 13,2 psia (90,7 kPa) bei einer Temperatur von etwa -25°C;
31,2 Gewichtsprozent HFC-1234yf, 26,2 Gewichtsprozent Isobutan und 42,6 Gewichtsprozent Dimethylether mit einem Dampfdruck von etwa 14,2 psia (97,8 kPa) bei einer Temperatur von etwa -25°C;
16,3 Gewichtsprozent HFC-1234yf, 10,0 Gewichtsprozent Dimethylether und 73,7 Gewichtsprozent CF₃I mit
30 einem Dampfdruck von etwa 15,7 psia (108 kPa) bei einer Temperatur von etwa -25°C; und
34,3 Gewichtsprozent HFC-1234yf, 10,5 Gewichtsprozent Dimethylether und 55,2 Gewichtsprozent CF₃SCF₃ mit einem Dampfdruck von etwa 14,6 psia (100 kPa) bei einer Temperatur von etwa -25°C.

8. Zusammensetzung wie in einem der Ansprüche 1-7, weiterhin umfassend ein Schmiermittel, ausgewählt aus der Gruppe, bestehend aus Polyolestern, Polyalkylenglycolen, Polyvinylethern, Mineralöl, Alkylbenzolen, synthetischen Paraffinen, synthetischen Naphthenen und Poly(alpha)olefinen.
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9. Zusammensetzung wie in einem der Ansprüche 1-7, weiterhin umfassend einen Tracer, ausgewählt aus der Gruppe, bestehend aus Fluorkohlenwasserstoffen, deuterierten Kohlenwasserstoffen, deuterierten Fluorkohlenwasserstoffen, Perfluorkohlenstoffen, Fluorethern, bromierten Verbindungen, iodierten Verbindungen, Alkoholen, Aldehyden, Ketonen, Distickstoffmonoxid (N₂O) und Kombinationen davon.
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10. Zusammensetzung nach einem der Ansprüche 1-7, weiterhin umfassend mindestens einen Ultraviolettfluoreszenzfarbstoff, ausgewählt aus der Gruppe, bestehend aus Naphthalimiden, Perylenen, Coumarinen, Anthracenen, Phenanthracenen, Xanthenen, Thioxanthenen, Naphthoxanthenen, Fluoresceinen, Derivaten des Farbstoffs und Kombinationen davon.
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11. Verfahren zum Nachweisen der Zusammensetzung nach Anspruch 10 in einer Kompressionskühl-, Klimaanlage- oder Wärmepumpenvorrichtung, wobei das Verfahren Bereitstellen der Zusammensetzung für die Vorrichtung und Bereitstellen eines geeigneten Mittels zum Nachweisen der Zusammensetzung an einem Leckpunkt oder in der Nachbarschaft der Vorrichtung umfasst.
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12. Verfahren zum Erzeugen von Kühlung, wobei das Verfahren umfasst: Verdampfen einer Zusammensetzung nach einem der Ansprüche 1-7 in der Nachbarschaft eines zu kühlenden Körpers und danach Kondensieren der Zusammensetzung.
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13. Verfahren zum Erzeugen von Erwärmung, wobei das Verfahren umfasst: Kondensieren einer Zusammensetzung nach einem der Ansprüche 1-7 in der Nachbarschaft eines zu erwärmenden Körpers und danach Verdampfen der Zusammensetzung.

14. Verfahren zum Ersetzen eines Kühlmittels mit hohem GWP in einer Kühl-, Klimaanlage- oder Wärmepumpenvorrichtung, in dem das Kühlmittel mit hohem GWP aus der Gruppe, bestehend aus R134a, R22, R123, R11, R245fa, R114, R236fa, R124, R12, R410A, R407C, R417A, R422A, R507A, R502 und R404A, ausgewählt ist, wobei das Verfahren Bereitstellen der Zusammensetzung nach einem der Ansprüche 1-7 für die Kühl-, Klimaanlage- oder Wärmepumpenvorrichtung umfasst, die das Kühlmittel mit hohem GWP verwendet, verwendet hat oder gestaltet ist zu verwenden.

15. Kühl-, Klimaanlage- oder Wärmepumpenvorrichtung, enthaltend eine Zusammensetzung, wie in einem der Ansprüche 1-7 beansprucht.

Revendications

1. Composition comprenant du HFC-1234yf et au moins un composé sélectionné dans le groupe constitué du: 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-méthylbutane, *n*-pentane, cyclopentane, éther de diméthyle et CF₃SCF₃;

ou composition sélectionnée dans le groupe constitué du HFC-1234yf, éther de diméthyle et CF₃I; HFC-1234yf, HFC-32 et CF₃I; HFC-1234yf, HFC-32, HFC-125 et CF₃I; et HFC-1234yf, HFC-32, HFC-134a et CF₃I.

2. Composition selon la revendication 1 sélectionnée dans le groupe constitué du:

HFC-1234yf et I4FC-134a; HFC-1234yf et HFC-152a; HFC-1234yf et HFC-32; HFC-1234yf, HFC-125 et *n*-butane; HFC-1234yf, HFC-32 et HFC-125; HFC-1234yf, HFC-125 et isobutane; HFC-1234yf, HFC-32 et HFC-143a; HFC-1234yf, HFC-32 et isobutane; HFC-1234yf, HFC-125 et HFC-143a; HFC-1234yf, HFC-125 et isobutane; HFC-1234yf, HFC-134 et propane; HFC-1234yf, HFC-134 et éther de diméthyle; HFC-1234yf, HFC-134a et propane; HFC-1234yf, HFC-134a et *n*-butane; HFC-1234yf, HFC-134a et isobutane; HFC-1234yf, HFC-134a et éther de diméthyle; HFC-1234yf, HFC-143a et propane; HFC-1234yf, HFC-143a et éther de diméthyle; HFC-1234yf, HFC-152a et *n*-butane; HFC-1234yf, HFC-152a et isobutane; HFC-1234yf, HFC-152a et éther de diméthyle; HFC-1234yf, HFC-227ea et propane; HFC-1234yf, HFC-227ea et *n*-butane; HFC-1234yf, HFC-227ea et isobutane; HFC-1234yf, HFC-227ea et éther de diméthyle; IIFC-1234yf, *n*-butane et éther de diméthyle; HFC-1234yf, isobutane et éther de diméthyle; HFC-1234yf, éther de diméthyle et CF₃SCF₃; et HFC-1234yf, HFC-32 et HFC-125.

3. Composition selon la revendication 1 sélectionnée dans le groupe constitué de:

environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-134a; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-32; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-152a; environ 0,1 pour cent en poids à environ 98 pour cent en poids de HFC-32, environ 0,1 pour cent en poids à environ 98 pour cent en poids de HFC-125, et environ 0,1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf; environ 0,1 pour cent en poids à environ 98 pour cent en poids de HFC-125, environ 0,1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, et environ 0,1 pour cent en poids à environ 98 pour cent en poids de *n*-butane; et environ 0,1 pour cent en poids à environ 98 pour cent en poids de HFC-125, environ 0,1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, et environ 0,1 pour cent en poids à environ 98 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 50 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-32 et environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-143a; environ 1 pour cent en poids à environ 40 pour cent en poids de HFC-1234yf, environ 59 pour cent en poids à environ 98 pour cent en poids de HFC-32 et environ 1 pour cent en poids à environ 30 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 60 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-125 et environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-143a; environ 1 pour cent en poids à environ 40 pour cent en poids de HFC-1234yf, environ 59 pour cent en poids à environ 98 pour cent en poids de HFC-125 et environ 1 pour cent en poids à environ 20 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 70 pour cent en poids de HFC-134 et environ 19 pour cent en poids à environ 90 pour cent en poids de propane; environ 1 pour cent en poids à environ 70 pour cent en poids de HFC-1234yf, environ 1 pour cent

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en poids de HFC-32 et environ 1 pour cent en poids à environ 80 pour cent en poids de CF₃I.

- 5 5. Composition selon la revendication 1 sélectionnée dans le groupe constitué de: environ 90 pour cent en poids de HFC-1234yf et environ 10 pour cent en poids de HFC-134a; environ 95 pour cent en poids de HFC-1234yf et environ 5 pour cent en poids de HFC-32; environ 80 pour cent en poids de HFC-1234yf et environ 20 pour cent en poids de HFC-152a, environ 40 pour cent en poids de HFC-32, environ 50 pour cent en poids de HFC-125, et environ 10 pour cent en poids de HFC-1234yf; environ 23 pour cent en poids de HFC-32, environ 25 pour cent en poids de HFC-125, et environ 52 pour cent en poids de HFC-1234yf; environ 15 pour cent en poids de HFC-32, environ 45 pour cent en poids de HFC-125, et environ 40 pour cent en poids de HFC-1234yf; environ 10 pour cent en poids de HFC-32, environ 60 pour cent en poids de HFC-125, et environ 30 pour cent en poids de HFC-1234yf; environ 67 pour cent en poids de HFC-125, environ 32 pour cent en poids de HFC-1234yf, et environ 1 pour cent en poids de *n*-butane; et environ 87,1 pour cent en poids de HFC-125, environ 11,5 pour cent en poids de HFC-1234yf, et environ 1,4 pour cent en poids d'isobutane.
- 10 6. Composition selon la revendication 1 comprenant une composition azéotrope ou quasi-azéotrope sélectionnée dans le groupe constitué de: environ 1 pour cent en poids à environ 57 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 43 pour cent en poids de HFC-32; environ 1 pour cent en poids à environ 51 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 49 pour cent en poids de HFC-125; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-134; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-134a; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-152a; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-161; environ 1 pour cent en poids à environ 60 pour cent en poids de HFC-1234yf et environ 40 pour cent en poids à environ 1 pour cent en poids de HFC-143a; environ 29 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 71 pour cent en poids à environ 1 pour cent en poids de HFC-227ea; environ 66 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 34 pour cent en poids à environ 1 pour cent en poids de HFC-236fa; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids de HFC-1243zf; environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 20 pour cent en poids de propane; environ 71 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 29 pour cent en poids à environ 1 pour cent en poids de *n*-butane; environ 60 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 40 pour cent en poids à environ 1 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 99 pour cent en poids de HFC-1234yf et environ 99 pour cent en poids à environ 1 pour cent en poids d'éther de diméthyle; environ 80 pour cent en poids à environ 98 pour cent en poids de HFC-125, environ 1 pour cent en poids à environ 19 pour cent en poids de HFC-1234yf, et environ 1 pour cent en poids à environ 10 pour cent en poids d'isobutane; environ 80 pour cent en poids à environ 98 pour cent en poids de HFC-125, environ 1 pour cent en poids à environ 19 pour cent en poids de HFC-1234yf, et environ 1 pour cent en poids à environ 10 pour cent en poids de *n*-butane; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-32, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-125, et environ 1 pour cent en poids à environ 55 pour cent en poids de HFC-1234yf; environ 1 pour cent en poids à environ 50 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-32 et environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-143a; environ 1 pour cent en poids à environ 40 pour cent en poids de HFC-1234yf, environ 59 pour cent en poids à environ 98 pour cent en poids de HFC-32 et environ 1 pour cent en poids à environ 30 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 60 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-125 et environ pour cent en poids à environ 98 pour cent en poids de HFC-143a; environ 1 pour cent en poids à environ 40 pour cent en poids de HFC-1234yf, environ 59 pour cent en poids à environ 98 pour cent en poids de HFC-125 et environ 1 pour cent en poids à environ 20 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 70 pour cent en poids de HFC-134 et environ 19 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-134 et environ 29 pour cent en poids à environ 98 pour cent en poids d'éther de diméthyle; environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-134a et environ 19 pour cent en poids à environ 98 pour cent en poids de propane; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-134a et environ 1 pour cent en poids à environ 30 pour cent en poids de *n*-butane; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-134a et environ 1 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-134a et environ

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1 pour cent en poids à environ 30 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-134a et environ 1 pour cent en poids à environ 40 pour cent en poids d'éther de diméthyle; environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-143a et environ 1 pour cent en poids à environ 98 pour cent en poids de propane; environ 1 pour cent en poids à environ 40 pour cent en poids de HFC-1234yf, environ 59 pour cent en poids à environ 98 pour cent en poids de HFC-143a et environ 1 pour cent en poids à environ 20 pour cent en poids d'éther de diméthyle; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-152a et environ 1 pour cent en poids à environ 30 pour cent en poids de *n*-butane; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 90 pour cent en poids de HFC-152a et environ 1 pour cent en poids à environ 40 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 70 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-152a et environ 1 pour cent en poids à environ 98 pour cent en poids d'éther de diméthyle; environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 70 pour cent en poids de HFC-227ea et environ 29 pour cent en poids à environ 98 pour cent en poids de propane; environ 40 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 59 pour cent en poids de HFC-227ea et environ 1 pour cent en poids à environ 20 pour cent en poids de *n*-butane; environ 30 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 69 pour cent en poids de HFC-227ea et environ 1 pour cent en poids à environ 30 pour cent en poids d'isobutane; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 80 pour cent en poids de HFC-227ea et environ 1 pour cent en poids à environ 98 pour cent en poids d'éther de diméthyle; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 40 pour cent en poids de *n*-butane et environ 1 pour cent en poids à environ 98 pour cent en poids d'éther de diméthyle; environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 50 pour cent en poids d'isobutane et environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids d'éther de diméthyle et environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 98 pour cent en poids de HFC-1234yf, environ 1 pour cent en poids à environ 40 pour cent en poids d'éther de diméthyle et environ 1 pour cent en poids à environ 98 pour cent en poids de CF₃SCF₃.

7. Composition selon la revendication 1 comprenant une composition azéotrope sélectionnée dans le groupe constitué de:

7,4 pour cent en poids de HFC-1234yf et 92,6 pour cent en poids de HFC-32 ayant une pression de vapeur d'environ 49,2 lb/po²(abs.) (339 kPa) à une température d'environ -25°C;
10,9 pour cent en poids de HFC-1234yf et 89,1 pour cent en poids de HFC-125 ayant une pression de vapeur d'environ 40,7 lb/po²(abs.) (281 kPa) à une température d'environ -25°C;
70,4 pour cent en poids de HFC-1234yf et 29,6 pour cent en poids de HFC-134a ayant une pression de vapeur d'environ 18,4 lb/po²(abs.) (127 kPa) à une température d'environ -25°C;
91,0 pour cent en poids de HFC-1234yf et 9,0 pour cent en poids de HFC-152a ayant une pression de vapeur d'environ 17,9 lb/po²(abs.) (123 kPa) à une température d'environ -25°C;
17,3 pour cent en poids de HFC-1234yf et 82,7 pour cent en poids de HFC-143a ayant une pression de vapeur d'environ 29,5 lb/po²(abs.) (272 kPa) à une température d'environ -25°C;
84,6 pour cent en poids de HFC-1234yf et 15,4 pour cent en poids de HFC-227ea ayant une pression de vapeur d'environ 18,0 lb/po²(abs.) (124 kPa) à une température d'environ -25°C;
51,5 pour cent en poids de HFC-1234yf et 48,5 pour cent en poids de propane ayant une pression de vapeur d'environ 33,5 lb/po²(abs.) (231 kPa) à une température d'environ -25°C;
98,1 pour cent en poids de HFC-1234yf et 1,9 pour cent en poids de *n*-butane; ayant une pression de vapeur d'environ 17,9 lb/po²(abs.) (123 kPa) à une température d'environ -25°C;
88,1 pour cent en poids HFC-1234yf et 11,9 pour cent en poids d'isobutane ayant une pression de vapeur d'environ 19,0 lb/po²(abs.) (131 kPa) à une température d'environ -25°C;
53,5 pour cent en poids de HFC-1234yf et 46,5 pour cent en poids d'éther de diméthyle ayant une pression de vapeur d'environ 13,1 lb/po²(abs.) (90 kPa) à une température d'environ -25°C;
89,1 pour cent en poids de HFC-125, 9,7 pour cent en poids de HFC-1234yf et 1,2 pour cent en poids d'isobutane ayant une pression de vapeur d'environ 40,8 lb/po²(abs.) (281 kPa) à une température d'environ -25°C;
3,9 pour cent en poids de HFC-1234yf, 74,3 pour cent en poids de HFC-32, et 21,8 pour cent en poids de HFC-143a ayant une pression de vapeur d'environ 50,0 lb/po²(abs.) (345 kPa) à une température d'environ -25°C;

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1,1 pour cent en poids de HFC-1234yf, 92,1 pour cent en poids de HFC-32 et 6,8 pour cent en poids d'isobutane ayant une pression de vapeur d'environ 50,0 lb/po²(abs.) (345 kPa) à une température d'environ -25°C;

5 14,4 pour cent en poids de HFC-1234yf, 43,5 pour cent en poids de HFC-125 et 42,1 pour cent en poids de HFC-143a ayant une pression de vapeur d'environ 38,6 lb/po²(abs.) (266 kPa) à une température d'environ -25°C;

10 4,3 pour cent en poids de HFC-1234yf, 39,1 pour cent en poids de HFC-134 et 56,7 pour cent en poids de propane ayant une pression de vapeur d'environ 34,3 lb/po²(abs.) (236 kPa) à une température d'environ -25°C;

15 15,2 pour cent en poids de HFC-1234yf, 67,0 pour cent en poids de HFC-134 et 17,8 pour cent en poids d'éther de diméthyle ayant une pression de vapeur d'environ 10,4 lb/po²(abs.) (71,6 kPa) à une température d'environ -25°C;

20 24,5 pour cent en poids de HFC-1234yf, 31,1 pour cent en poids de HFC-134a et 44,5 pour cent en poids de propane ayant une pression de vapeur d'environ 34,0 lb/po²(abs.) (234 kPa) à une température d'environ -25°C;

25 60,3 pour cent en poids de HFC-1234yf, 35,2 pour cent en poids de HFC-134a et 4,5 pour cent en poids de *n*-butane ayant une pression de vapeur d'environ 18,6 lb/po²(abs.) (128 kPa) à une température d'environ -25°C;

30 48,6 pour cent en poids de HFC-1234yf, 37,2 pour cent en poids de HFC-134a et 14,3 pour cent en poids d'isobutane ayant une pression de vapeur d'environ 19,9 lb/po²(abs.) (137 kPa) à une température d'environ -25°C;

35 24,0 pour cent en poids de HFC-1234yf, 67,9 pour cent en poids de HFC-134a et 8,1 pour cent en poids d'éther de diméthyle ayant une pression de vapeur d'environ 17,2 lb/po²(abs.) (119 kPa) à une température d'environ -25°C;

40 17,7 pour cent en poids de HFC-1234yf, 71,0 pour cent en poids de HFC-143a et 11,3 pour cent en poids de propane ayant une pression de vapeur d'environ 40,4 lb/po²(abs.) (279 kPa) à une température d'environ -25°C;

45 5,7 pour cent en poids de HFC-1234yf, 93,0 pour cent en poids de HFC-143a et 1,3 pour cent en poids d'éther de diméthyle ayant une pression de vapeur d'environ 39,1 lb/po²(abs.) (269 kPa) à une température d'environ -25°C;

50 86,6 pour cent en poids de HFC-1234yf, 10,8 pour cent en poids de HFC-152a et 2,7 pour cent en poids de *n*-butane ayant une pression de vapeur d'environ 18,0 lb/po²(abs.) (124 kPa) à une température d'environ -25°C;

55 75,3 pour cent en poids de HFC-1234yf, 11,8 pour cent en poids de HFC-152a et 12,9 pour cent en poids d'isobutane ayant une pression de vapeur d'environ 19,1 lb/po²(abs.) (132 kPa) à une température d'environ -25°C;

24,6 pour cent en poids de HFC-1234yf, 43,3 pour cent en poids de HFC-152a et 32,1 pour cent en poids d'éther de diméthyle ayant une pression de vapeur d'environ 11,8 lb/po²(abs.) (81,2 kPa) à une température d'environ -25°C;

35,6 pour cent en poids de HFC-1234yf, 17,8 pour cent en poids de HFC-227ea et 46,7 pour cent en poids de propane ayant une pression de vapeur d'environ 33,8 lb/po²(abs.) (233 kPa) à une température d'environ -25°C;

81,9 pour cent en poids de HFC-1234yf, 16,0 pour cent en poids de HFC-227ea et 2,1 pour cent en poids de *n*-butane ayant une pression de vapeur d'environ 18,1 lb/po²(abs.) (125 kPa) à une température d'environ -25°C;

40 86,6 pour cent en poids de HFC-1234yf, 10,8 pour cent en poids de HFC-152a et 2,7 pour cent en poids de *n*-butane ayant une pression de vapeur d'environ 18,0 lb/po²(abs.) (124 kPa) à une température d'environ -25°C;

70,2 pour cent en poids de HFC-1234yf, 18,2 pour cent en poids de HFC-227ea et 11,6 pour cent en poids d'isobutane ayant une pression de vapeur d'environ 19,3 lb/po²(abs.) (133 kPa) à une température d'environ -25°C;

28,3 pour cent en poids de HFC-1234yf, 55,6 pour cent en poids de HFC-227ea et 16,1 pour cent en poids d'éther de diméthyle ayant une pression de vapeur d'environ 15,0 lb/po²(abs.) (104 kPa) à une température d'environ -25°C;

48,9 pour cent en poids de HFC-1234yf, 4,6 pour cent en poids de *n*-butane et 46,4 pour cent en poids d'éther de diméthyle; ayant une pression de vapeur d'environ 13,2 lb/po²(abs.) (90,7 kPa) à une température d'environ -25°C;

31,2 pour cent en poids de HFC-1234yf, 26,2 pour cent en poids d'isobutane et 42,6 pour cent en poids d'éther de diméthyle ayant une pression de vapeur d'environ 14,2 lb/po²(abs.) (97,8 kPa) à une température d'environ -25°C;

16,3 pour cent en poids de HFC-1234yf, 10,0 pour cent en poids d'éther de diméthyle et 73,7 pour cent en poids de CF₃I ayant une pression de vapeur d'environ 15,7 lb/po²(abs.) (108 kPa) à une température d'environ -25°C; et

34,3 pour cent en poids de HFC-1234yf, 10,5 pour cent en poids d'éther de diméthyle et 55,2 pour cent en poids de CF₃SCF₃ ayant une pression de vapeur d'environ 14,6 lb/po²(abs.) (100 kPa) à une température d'environ -25°C.

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8. Composition selon l'une quelconque des revendications 1 à 7, comprenant en outre un lubrifiant sélectionné dans le groupe constitué des esters de polyol, des polyalkylène glycols, des poly(éthers de vinyle), de l'huile minérale, des alkylbenzènes, des paraffines synthétiques, des naphènes synthétiques, et des poly(alpha)oléfines.
- 5 9. Composition selon l'une quelconque des revendications 1 à 7, comprenant en outre un traceur sélectionné dans le groupe constitué des hydrocarbures fluorés, des hydrocarbures deutériés, des hydrocarbures fluorés deutériés, des hydrocarbures perfluorés, des éthers fluorés, des composés bromés, des composés iodés, des alcools, des aldéhydes, des cétones, de l'oxyde nitreux (N₂O) et de leurs combinaisons.
- 10 10. Composition selon l'une quelconque des revendications 1 à 7, comprenant en outre au moins un colorant fluorescent ultraviolet sélectionné dans le groupe constitué des naphthalimides, pérylènes, coumarines, anthracènes, phénanthracènes, xanthènes, thioxanthènes, naphtoxanthènes, fluorescéines, dérivés dudit colorant et leurs combinaisons.
- 15 11. Procédé de détection de la composition selon la revendication 10 dans un appareil de réfrigération par compression, un conditionnement d'air, ou une pompe à chaleur, ledit procédé comprenant la fourniture de ladite composition audit appareil, et la fourniture d'un moyen approprié pour détecter ladite composition au niveau d'un point de fuite ou à proximité dudit appareil.
- 20 12. Procédé de production de refroidissement, ledit procédé comprenant: l'évaporation d'une composition selon l'une quelconque des revendications 1 à 7 à proximité d'un corps à refroidir et par la suite la condensation de ladite composition.
- 25 13. Procédé de production de chauffage, ledit procédé comprenant: la condensation d'une composition selon l'une quelconque des revendications 1 à 7 à proximité d'un corps à chauffer et par la suite l'évaporation de ladite composition.
- 30 14. Procédé de remplacement d'une substance réfrigérante à potentiel PRP élevé dans un appareil de réfrigération, de conditionnement d'air, ou de pompe à chaleur, ladite substance réfrigérante à potentiel PRP élevé étant sélectionnée dans le groupe constitué de R134a, R22, R123, RA11, R245fa, R114, R236fa, R124, R12, R410A, R407C, R417A, R422A, R507A, R502, et R404A, ledit procédé comprenant la fourniture de la composition selon l'une quelconque des revendications 1 à 7 audit appareil de réfrigération, conditionnement d'air, ou pompe à chaleur qui utilise, a utilisé ou est conçu(e) pour utiliser ladite substance réfrigérante à potentiel PRP élevé.
- 35 15. Appareil de réfrigération, de conditionnement d'air, ou de pompe à chaleur contenant une composition telle que revendiquée selon l'une quelconque des revendications 1 à 7.

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REFERENCES CITED IN THE DESCRIPTION

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Szabadalmi igénypontok

1. Kompozíció, amely tartalmaz HFC-1234yf-t és legalább egy vegyületet, amely ki van választva a következőkből álló csoportból: 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, propán, n-bután, izobután, 2-metilbután, n-pentán, ciklopentán, dimetiléter és CF_3SCF_3 ;

5 vagy kompozíció, amely ki van választva a következőkből álló csoportból: HFC-1234yf, dimetiléter és CF_3I ; HFC-1234yf, HFC-32 és CF_3I ; HFC-1234yf, HFC-32, HFC-125 és CF_3I ; és HFC-1234yf, HFC-32, HFC-134a és CF_3I .

2. Az 1. igénypont szerinti kompozíció, amely ki van választva a következőket tartalmazó csoportból:
10 HFC-1234yf és HFC-134a; HFC-1234yf és HFC-152a; HFC-1234yf és HFC-32; HFC-1234yf, HFC-125 és n-bután; HFC-1234yf, HFC-32 és HFC-125; HFC-1234yf, HFC-125 és izobután; HFC-1234yf, HFC-32 és HFC-143a; HFC-1234yf, HFC-32 és izobután; HFC-1234yf, HFC-125 és HFC-143a; HFC-1234yf, HFC-125 és izobután; HFC-1234yf, HFC-134 és propán; HFC-1234yf, HFC-134 és dimetiléter; HFC-1234yf, HFC-134a és propán; HFC-1234yf, HFC-134a és n-bután; HFC-1234yf, HFC-134a és izobután; HFC-1234yf, HFC-134a és dimetiléter; HFC-1234yf, HFC-143a és propán; HFC-1234yf, HFC-143a és dimetiléter; HFC-1234yf, HFC-152a és n-bután; HFC-1234yf, HFC-152a és izobután; HFC-1234yf, HFC-152a és dimetiléter; HFC-1234yf, HFC-227ea és propán; HFC-1234yf, HFC-227ea és n-bután; HFC-1234yf, HFC-227ea és izobután; HFC-1234yf, HFC-227ea és dimetiléter; HFC-1234yf, n-bután és dimetiléter; HFC-1234yf, izobután és dimetiléter; HFC-1234yf, dimetiléter és CF_3SCF_3 ; és HFC-20 1234yf, HFC-32 és HFC-125.

3. Az 1. igénypont szerinti kompozíció, amely ki van választva a következőket tartalmazó csoportból:
körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-134a; körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-32;
25 körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234y és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-152a; körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-32, körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-125, és körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf; körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-125, körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, és körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig n-bután; és körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-125, körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, és körülbelül 0,1 tömegszázaléktól körülbelül 98 tömegszázalékig izobután; körülbelül 1 tömegszázaléktól körülbelül 50 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-143a; körülbelül 1 tömegszázaléktól körülbelül 40 tömegszázalékig HFC-1234yf, körülbelül 59 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 30 tömegszázalékig izobután; körülbelül 1 tömegszázaléktól körülbelül 60 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-125 és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-143a; körülbelül 1 tömegszázaléktól körülbelül 40 tömegszázalékig HFC-1234yf, körülbelül 59 tömegszázaléktól körülbelül

tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 40 tömegszázalékig dimetiléter és körülbelül 1 tömegszázaléktól körülbelül 98 v tömegszázalékig CF_3SCF_3 ; körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-125; körülbelül 1
5 tömegszázaléktól körülbelül 97 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 97 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 97 tömegszázalékig HFC-125 és körülbelül 1 tömegszázaléktól körülbelül 97 tömegszázalékig CF_3I ; körülbelül 1 tömegszázaléktól körülbelül 97 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 97 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 97 tömegszázalékig HFC-134a és körülbelül 1
10 tömegszázaléktól körülbelül 97 tömegszázalékig CF_3I ; és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig CF_3I .

4. Az 1. igénypont szerinti kompozíció, amely ki van választva a következőket tartalmazó csoportból: körülbelül 30 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 70
15 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-134a; körülbelül 40 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 60 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-32; körülbelül 40 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 60 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-152a körülbelül 5 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-32, körülbelül 5 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-125, és
20 körülbelül 5 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-1234yf; körülbelül 5 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-125, körülbelül 5 tömegszázaléktól 70 tömegszázalékig HFC-1234yf, és körülbelül 1 tömegszázaléktól körülbelül 20 tömegszázalékig n- bután; körülbelül 5 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-125, körülbelül 5 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-1234yf, és körülbelül 1 tömegszázaléktól körülbelül 20 tömegszázalékig izobután; körülbelül 15
25 tömegszázaléktól körülbelül 50 tömegszázalékig HFC-1234yf, körülbelül 20 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-32 és körülbelül 5 tömegszázaléktól körülbelül 60 tömegszázalékig HFC-143a; körülbelül 10 tömegszázaléktól körülbelül 40 tömegszázalékig HFC-1234yf, körülbelül 59 tömegszázaléktól körülbelül 90 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 10 tömegszázalékig izobután; körülbelül 10 tömegszázaléktól körülbelül 60 tömegszázalékig HFC-1234yf;
30 körülbelül 20 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-125 és körülbelül 20 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-143a; körülbelül 10 tömegszázaléktól körülbelül 40 tömegszázalékig HFC-1234yf, körülbelül 59 tömegszázaléktól körülbelül 90 tömegszázalékig HFC-125 és körülbelül 1 tömegszázaléktól körülbelül 10 tömegszázalékig izobután; körülbelül 20 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-1234yf, körülbelül 10 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-134 és
35 körülbelül 19 tömegszázaléktól körülbelül 50 tömegszázalékig propán; körülbelül 20 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-1234yf, körülbelül 10 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-134 és körülbelül 29 tömegszázaléktól körülbelül 50 tömegszázalékig dimetiléter; körülbelül 10 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-1234yf, körülbelül 10 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-134a és körülbelül 19 tömegszázaléktól körülbelül 50 tömegszázalékig propán;
40 körülbelül 10 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-1234yf, körülbelül 10

HFC-32 és körülbelül 5 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-134a és körülbelül 5 tömegszázaléktól körülbelül 70 tömegszázalékig CF₃I; és körülbelül 10 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 70 tömegszázalékig HFC-32 és körülbelül 1 tömegszázaléktól körülbelül 80 tömegszázalékig CF₃I.

5. Az 1. igénypont szerinti kompozíció, amely ki van választva a következőkből álló csoportból: körülbelül 90 tömegszázalékig HFC-1234yf és körülbelül 10 tömegszázalékig HFC-134a; körülbelül 95 tömegszázalékig HFC-1234yf és körülbelül 5 tömegszázalékig HFC-32; körülbelül 80 tömegszázalékig HFC-1234yf és körülbelül 20 tömegszázalékig HFC-152a körülbelül 40 tömegszázalékig HFC-32, körülbelül 50 tömegszázalékig HFC-125, és körülbelül 10 tömegszázalékig HFC-1234yf; körülbelül 23 tömegszázalékig HFC-32, körülbelül 25 tömegszázalékig HFC-125, és körülbelül 52 tömegszázalékig HFC-1234yf; körülbelül 15 tömegszázalékig HFC-32, körülbelül 45 tömegszázalékig HFC-125, és körülbelül 40 tömegszázalékig HFC-1234yf; körülbelül 10 tömegszázalékig HFC-32, körülbelül 60 tömegszázalékig HFC-125, és körülbelül 30 tömegszázalékig HFC-1234yf; körülbelül 67 tömegszázalékig HFC-125, körülbelül 32 tömegszázalékig HFC-1234yf, és körülbelül 1 tömegszázalékig n-bután; és körülbelül 87.1 tömegszázalékig HFC-125, körülbelül 11.5 tömegszázalékig HFC-1234yf, és körülbelül 1.4 tömegszázalékig izobután.

6. Az 1. igénypont szerinti kompozíció, amely tartalmaz azeotróp vagy közel azeotróp kompozíciót, amely ki van választva a következőket tartalmazó csoportból: körülbelül 1 tömegszázaléktól körülbelül 57 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 43 tömegszázalékig HFC-32; körülbelül 1 tömegszázaléktól körülbelül 51 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 49 tömegszázalékig HFC-125; körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-134a; körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-134a; körülbelül 1 tömegszázalékig HFC-152a; körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-161; körülbelül 1 tömegszázaléktól körülbelül 60 tömegszázalékig HFC-1234yf és körülbelül 40 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-143a; körülbelül 29 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 71 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-227ea; körülbelül 66 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 34 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-236fa; körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig HFC-1243zf; körülbelül 1 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 20 tömegszázalékig propán; körülbelül 71 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 29 tömegszázaléktól körülbelül 1 tömegszázalékig n-bután; körülbelül 60 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 40 tömegszázaléktól körülbelül 1 tömegszázalékig izobután; körülbelül 1 tömegszázaléktól körülbelül 99 tömegszázalékig HFC-1234yf és körülbelül 99 tömegszázaléktól körülbelül 1 tömegszázalékig dimetiléter; körülbelül 80 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-125, körülbelül 1 tömegszázaléktól körülbelül 19 tömegszázalékig HFC-1234yf, és

körülbelül 1 tömegszázaléktól körülbelül 59 tömegszázalékig HFC-227ea és körülbelül 1 tömegszázaléktól körülbelül 20 tömegszázalékig n-bután; körülbelül 30 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 69 tömegszázalékig HFC-227ea és körülbelül 1 tömegszázaléktól körülbelül 30 tömegszázalékig izobután; körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 80 tömegszázalékig HFC-227ea és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig dimetiléter; körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 40 tömegszázalékig n-bután és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig dimetiléter; körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 50 tömegszázalékig izobután és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig dimetiléter; körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig dimetiléter és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig CF_3I ; és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig HFC-1234yf, körülbelül 1 tömegszázaléktól körülbelül 40 tömegszázalékig dimetiléter és körülbelül 1 tömegszázaléktól körülbelül 98 tömegszázalékig CF_3SCF_3 .

7. Az 1. igénypont szerinti kompozíció, amely tartalmaz azeotróp kompozíciót, amely ki van választva a következőket tartalmazó csoportból:

7,4 tömegszázalék HFC-1234yf és 92,6 tömegszázalék HFC-32, amelynek gőznyomása körülbelül 49,2 psia (339 kPa) körülbelül -25 °C hőmérsékleten;

20 10,9 tömegszázalék HFC-1234yf és 89,1 tömegszázalék HFC-125, amelynek gőznyomása körülbelül 40,7 psia (281 kPa) körülbelül -25 °C hőmérsékleten;

70,4 tömegszázalék HFC-1234yf és 29,6 tömegszázalék HFC-134a, amelynek gőznyomása körülbelül 18,4 psia (127 kPa) körülbelül -25 °C hőmérsékleten;

25 91,0 tömegszázalék HFC-1234yf és 9,0 tömegszázalék HFC-152a, amelynek gőznyomása körülbelül 17,9 psia (123 kPa) körülbelül -25 °C hőmérsékleten;

17,3 tömegszázalék HFC-1234yf és 82,7 tömegszázalék HFC-143a, amelynek gőznyomása körülbelül 29,5 psia (272 kPa) körülbelül -25 °C hőmérsékleten;

84,6 tömegszázalék HFC-1234yf és 15,4 tömegszázalék HFC-227ea, amelynek gőznyomása körülbelül 18,0 psia (124 kPa) körülbelül -25 °C hőmérsékleten;

30 51,5 tömegszázalék HFC-1234yf és 48,5 tömegszázalék propán, amelynek gőznyomása körülbelül 33,5 psia (231 kPa) körülbelül -25 °C hőmérsékleten;

98,1 tömegszázalék HFC-1234yf és 1,9 tömegszázalék n-bután, amelynek gőznyomása körülbelül 17,9 psia (123 kPa) körülbelül -25 °C hőmérsékleten;

35 88,1 tömegszázalék HFC-1234yf és 11,9 tömegszázalék izobután, amelynek gőznyomása körülbelül 19,0 psia (131 kPa) körülbelül -25 °C hőmérsékleten;

53,5 tömegszázalék HFC-1234yf és 46,5 tömegszázalék dimetiléter, amelynek gőznyomása körülbelül 13,1 psia (90 kPa) körülbelül -25 °C hőmérsékleten;

89,1 tömegszázalék HFC-125, 9,7 tömegszázalék HFC-1234yf és 1,2 tömegszázalék izobután, amelynek gőznyomása körülbelül 40,8 psia (281 kPa) körülbelül -25 °C hőmérsékleten;

- 3,9 tömegszázalék HFC-1234yf, 74,3 tömegszázalék HFC-32, és 21,8 tömegszázalék HFC-143a, amelynek gőznyomása körülbelül 50,0 psia (345 kPa) körülbelül -25 °C hőmérsékleten;
- 1,1 tömegszázalék HFC-1234yf, 92,1 tömegszázalék HFC-32 és 6,8 tömegszázalék izobután, amelynek gőznyomása körülbelül 50,0 psia (345 kPa) körülbelül -25 °C hőmérsékleten;
- 5 14,4 tömegszázalék HFC-1234yf, 43,5 tömegszázalék HFC-125 és 42,1 tömegszázalék HFC-143a, amelynek gőznyomása körülbelül 38,6 psia (266 kPa) körülbelül -25 °C hőmérsékleten;
- 4,3 tömegszázalék HFC-1234yf, 39,1 tömegszázalék HFC-134 és 56,7 tömegszázalék propán, amelynek gőznyomása körülbelül 34,3 psia (236 kPa) körülbelül -25 °C hőmérsékleten;
- 15,2 tömegszázalék HFC-1234yf, 67,0 tömegszázalék HFC-134 és 17,8 tömegszázalék dimetiléter, 10 amelynek gőznyomása körülbelül 10,4 psia (71,6 kPa) körülbelül -25 °C hőmérsékleten;
- 24,5 tömegszázalék HFC-1234yf, 31,1 tömegszázalék HFC-134a és 44,5 tömegszázalék propán, amelynek gőznyomása körülbelül 34,0 psia (234 kPa) körülbelül -25 °C hőmérsékleten;
- 60,3 tömegszázalék HFC-1234yf, 35,2 tömegszázalék HFC-134a és 4,5 tömegszázalék n-bután, amelynek gőznyomása körülbelül 18,6 psia (128 kPa) körülbelül -25 °C hőmérsékleten;
- 15 48,6 tömegszázalék HFC-1234yf, 37,2 tömegszázalék HFC-134a és 14,3 tömegszázalék izobután, amelynek gőznyomása körülbelül 19,9 psia (137 kPa) körülbelül -25 °C hőmérsékleten;
- 24,0 tömegszázalék HFC-1234yf, 67,9 tömegszázalék HFC-134a és 8,1 tömegszázalék dimetiléter, amelynek gőznyomása körülbelül 17,2 psia (119 kPa) körülbelül -25 °C hőmérsékleten;
- 17,7 tömegszázalék HFC-1234yf, 71,0 tömegszázalék HFC-143a és 11,3 tömegszázalék propán, 20 amelynek gőznyomása körülbelül 40,4 psia (279 kPa) körülbelül -25 °C hőmérsékleten;
- 5,7 tömegszázalék HFC-1234yf, 93,0 tömegszázalék HFC-143a és 1,3 tömegszázalék dimetiléter, amelynek gőznyomása körülbelül 39,1 psia (269 kPa) körülbelül -25 °C hőmérsékleten;
- 86,6 tömegszázalék HFC-1234yf, 10,8 tömegszázalék HFC-152a és 2,7 tömegszázalék n-bután, amelynek gőznyomása körülbelül 18,0 psia (124 kPa) körülbelül -25 °C hőmérsékleten;
- 25 75,3 tömegszázalék HFC-1234yf, 11,8 tömegszázalék HFC-152a és 12,9 tömegszázalék izobután, amelynek gőznyomása körülbelül 19,1 psia (132 kPa) körülbelül -25 °C hőmérsékleten ;
- 24,6 tömegszázalék HFC-1234yf, 43,3 tömegszázalék HFC-152a és 32,1 tömegszázalék dimetiléter, amelynek gőznyomása körülbelül 11,8 psia (81,2 kPa) körülbelül -25 °C hőmérsékleten;
- 35,6 tömegszázalék HFC-1234yf, 17,8 tömegszázalék HFC-227ea és 46,7 tömegszázalék propán, 30 amelynek gőznyomása körülbelül 33,8 psia (233 kPa) körülbelül -25 °C hőmérsékleten;
- 81,9 tömegszázalék HFC-1234yf, 16,0 tömegszázalék HFC-227ea és 2,1 tömegszázalék n-bután, amelynek gőznyomása körülbelül 18,1 psia (125 kPa) körülbelül -25 °C hőmérsékleten;
- 86,6 tömegszázalék HFC-1234yf, 10,8 tömegszázalék HFC-152a és 2,7 tömegszázalék n-bután, amelynek gőznyomása körülbelül 18,0 psia (124 kPa) körülbelül -25 °C hőmérsékleten;
- 35 70,2 tömegszázalék HFC-1234yf, 18,2 tömegszázalék HFC-227ea és 11,6 tömegszázalék izobután, amelynek gőznyomása körülbelül 19,3 psia (133 kPa) körülbelül -25 °C hőmérsékleten;
- 28,3 tömegszázalék HFC-1234yf, 55,6 tömegszázalék HFC-227ea és 16,1 tömegszázalék dimetiléter, amelynek gőznyomása körülbelül 15,0 psia (104 kPa) körülbelül -25 °C hőmérsékleten;

48,9 tömegszázalék HFC-1234yf, 4,6 tömegszázalék n- bután és 46,4 tömegszázalék dimetiléter, amelynek göznyomása körülbelül 13,2 psia (90,7 kPa) körülbelül -25 °C hőmérsékleten;

31,2 tömegszázalék HFC-1234yf, 26,2 tömegszázalék izobután és 42,6 tömegszázalék dimetiléter, amelynek göznyomása körülbelül 14,2 psia (97,8 kPa) körülbelül -25 °C hőmérsékleten;

5 16,3 tömegszázalék HFC-1234yf, 10,0 tömegszázalék dimetiléter és 73,7 tömegszázalék CF₃I, amelynek göznyomása körülbelül 15,7 psia (108 kPa) körülbelül -25 °C hőmérsékleten; és

34,3 tömegszázalék HFC-1234yf, 10,5 tömegszázalék dimetiléter és 55,2 tömegszázalék CF₃SCF₃, amelynek göznyomása körülbelül 14,6 psia (100 kPa) körülbelül -25 °C hőmérsékleten,

8. Az 1-7. igénypontok bármelyike szerinti kompozíció, amely továbbá tartalmaz kenőanyagot, 10 amely ki van választva a következőket tartalmazó csoportból: poliol észterek, polialkén glikolok, polivinil éterek, ásványolaj, alkilbenzolok, szintetikus paraffinok, szintetikus naftének, és poli(alfa)olefinok.

9. Az 1-7. igénypontok bármelyike szerinti kompozíció, amely továbbá tartalmaz nyomjelző anyagot, amely ki van választva a következőket tartalmazó csoportból: fluor-szénhidrogének, deuterizált 15 szénhidrogének, deuterizált fluor-szénhidrogének, perfluorkarbonok, fluoréterek, bromozott vegyületek, jódozott vegyületek, alkoholok, aldehidek, ketonok, nitrogénmonoxid (N₂O) és azok kombinációi.

10. Az 1-7. igénypontok bármelyike szerinti kompozíció, amely továbbá tartalmaz legalább egy ultraibolya fluoreszcens festék, amely ki van választva a következőket tartalmazó csoportból: naftalimidek, 20 perilének, kumarinok, antracének, fenantracénok, xantének, tioxantének, naftoxantének, fluoreszcének, a festék származékai és azok kombinációi.

11. Eljárás a 10. igénypont szerinti kompozíció kimutatására, kompressziós hűtésben, léghkondicionálásban vagy hőszivattyú berendezésben, az eljárás tartalmazza a kompozíció rendelkezésre 25 bocsátását a berendezés számára és rendelkezésre bocsátunk alkalmas eszközöket a kompozíció kimutatására a szivárgási helyen vagy a berendezés közelében.

12. Eljárás hűtés előállítására, amely eljárás tartalmazza: az 1-7. igénypontok bármelyike szerinti 25 kompozíciót elpárologtatjuk a hűtendő test környezetében és azután kondenzáljuk a kompozíciót.

13. Eljárás melegítés előállítására, amely eljárás tartalmazza: az 1-7. igénypontok bármelyike szerinti kompozíciót kondenzáljuk a melegítendő test környezetében és azután elgőzöltetjük a kompozíciót.

14. Nagy GWP-jű hűtőanyag helyettesítésére hűtő, léghkondicionáló vagy hőszivattyú berendezésben, ahol a nagy GWP-jű hűtőanyag ki van választva a következőket tartalmazó csoportból: R134a, R22, 30 R123, R11, R245fa, R114, R236fa, R124, R12, R410A, R407C, R417A, R422A, R507A, R502, és R404A, az eljárás tartalmazza az 1-7. igénypontok bármelyike szerinti kompozíció rendelkezésre bocsátását hűtő, léghkondicionáló vagy hőszivattyú berendezésben, amely nagy GWP-jű hűtőanyagot használ, használt vagy arra van kialakítva.

15. Hűtő, léghkondicionáló vagy hőszivattyú berendezés, amely az 1-7. igénypontok bármelyike 35 szerinti kompozíciót tartalmaz.

Lu de Vals