



(19) **United States**

(12) **Patent Application Publication** (10) **Pub. No.: US 2020/0339856 A1**

ITANO et al.

(43) **Pub. Date: Oct. 29, 2020**

(54) **REFRIGERATING OIL FOR REFRIGERANT OR REFRIGERANT COMPOSITION, METHOD FOR USING REFRIGERATING OIL, AND USE OF REFRIGERATING OIL**

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(21) Appl. No.: **16/954,651**

(22) PCT Filed: **Nov. 13, 2018**

(86) PCT No.: **PCT/JP2018/042032**

§ 371 (c)(1),

(2) Date: **Jun. 17, 2020**

(30) **Foreign Application Priority Data**

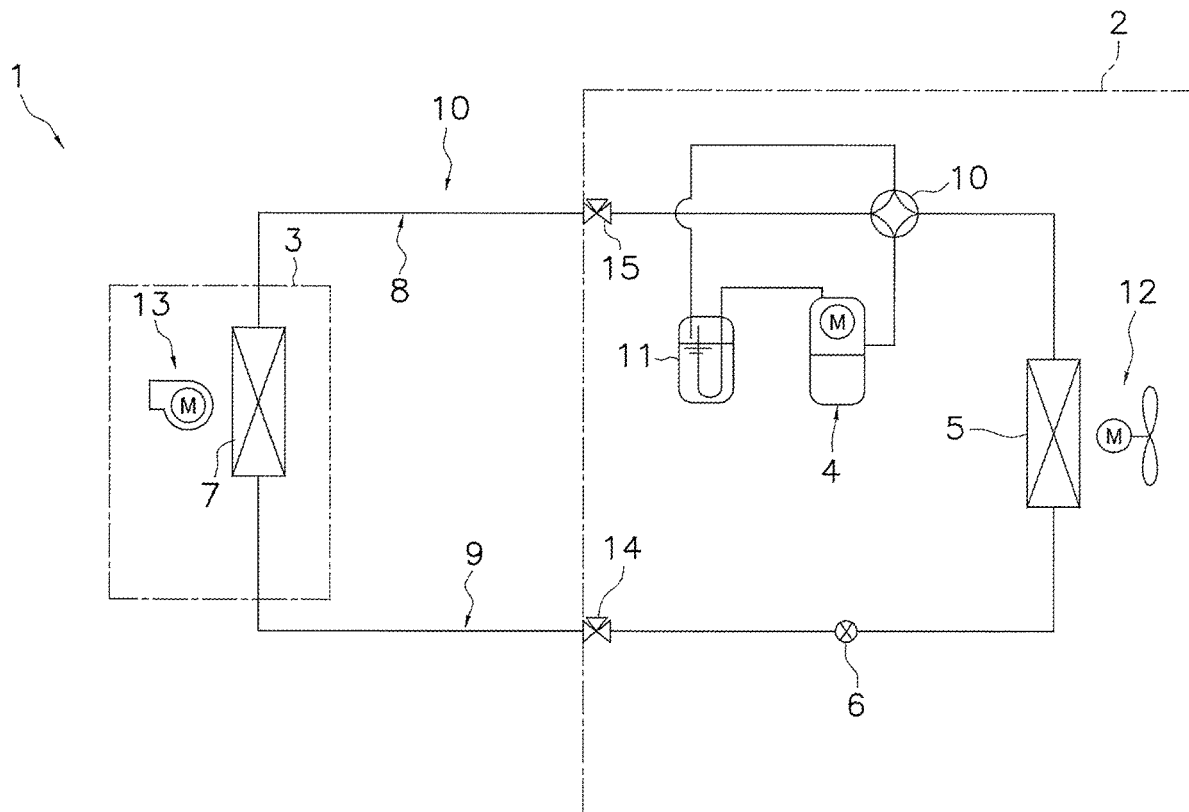
Dec. 18, 2017	(JP)	2017-242183
Dec. 18, 2017	(JP)	2017-242185
Dec. 18, 2017	(JP)	2017-242186
Dec. 18, 2017	(JP)	2017-242187
Oct. 5, 2018	(JP)	PCT/JP2018/037483
Oct. 17, 2018	(JP)	PCT/JP2018/038746
Oct. 17, 2018	(JP)	PCT/JP2018/038747
Oct. 17, 2018	(JP)	PCT/JP2018/038748
Oct. 17, 2018	(JP)	PCT/JP2018/038749

Publication Classification

- (51) **Int. Cl.**
C09K 5/04 (2006.01)
- (52) **U.S. Cl.**
CPC *C09K 5/045* (2013.01); *C09K 2205/22* (2013.01); *C09K 2205/126* (2013.01)

(57) **ABSTRACT**

There are provided a refrigerating oil for refrigerant compositions in which good lubricity can be achieved when a refrigeration cycle is performed using a refrigerant having a sufficiently low GWP, a method for using the refrigerating oil, and use of the refrigerating oil. The refrigerating oil for a refrigerant composition contains a refrigerant containing trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and 2,3,3,3-tetrafluoro-1-propene (R1234yf).



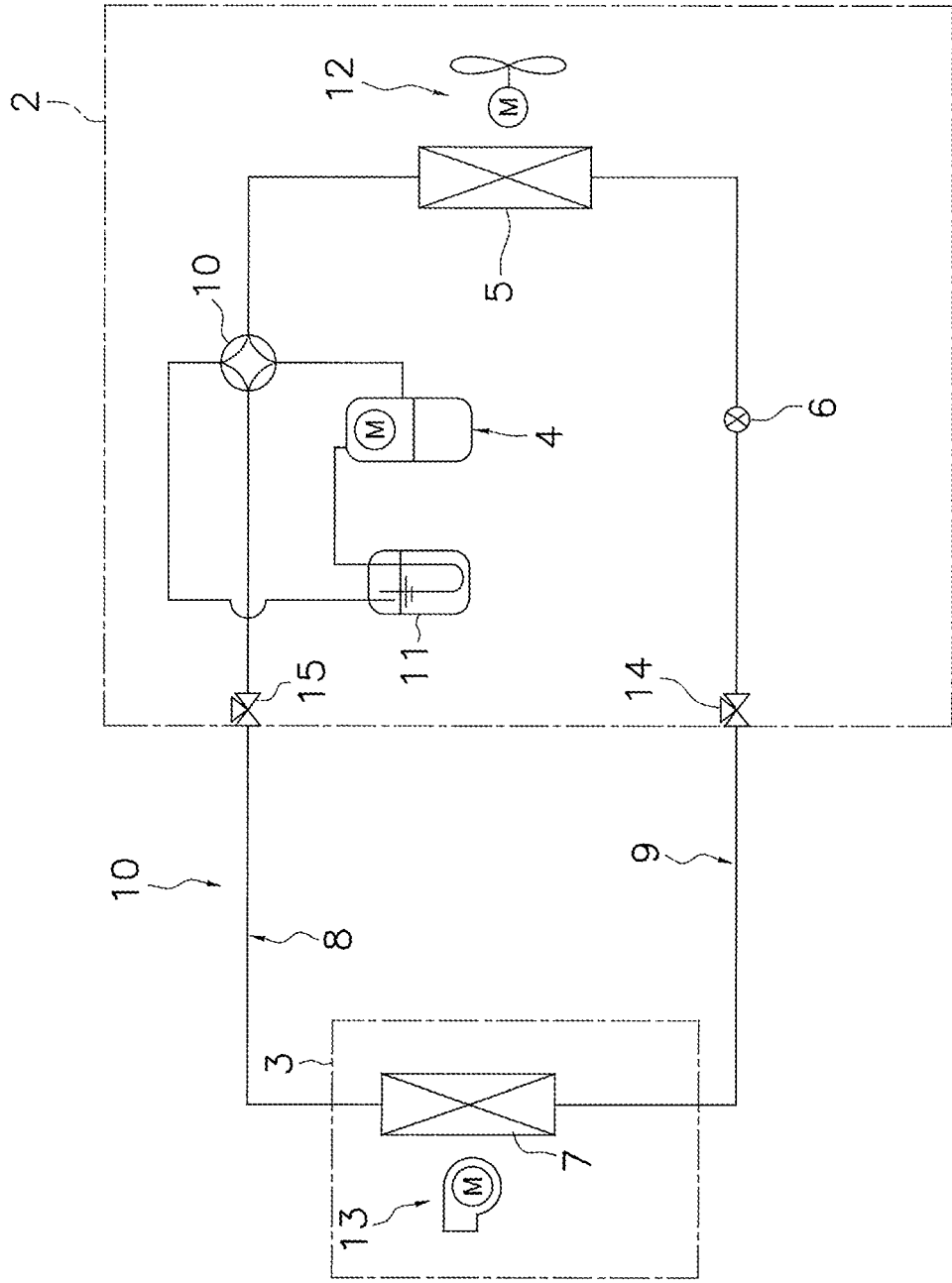


FIG. 1

Fig. 2

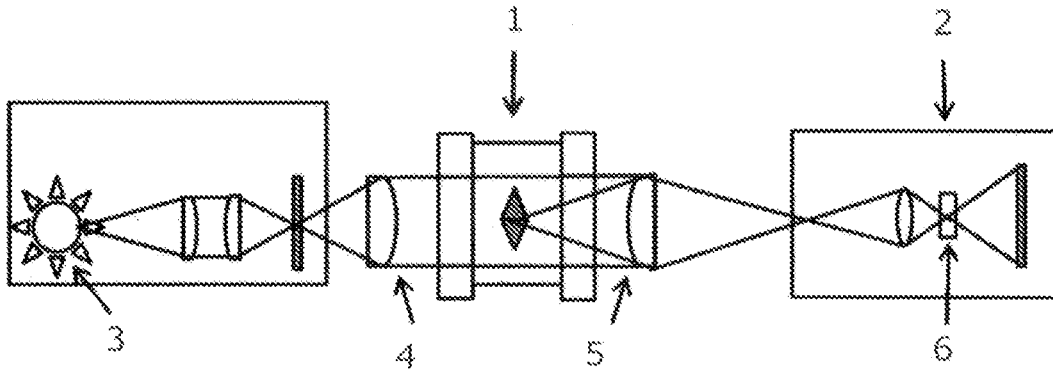


Fig. 3

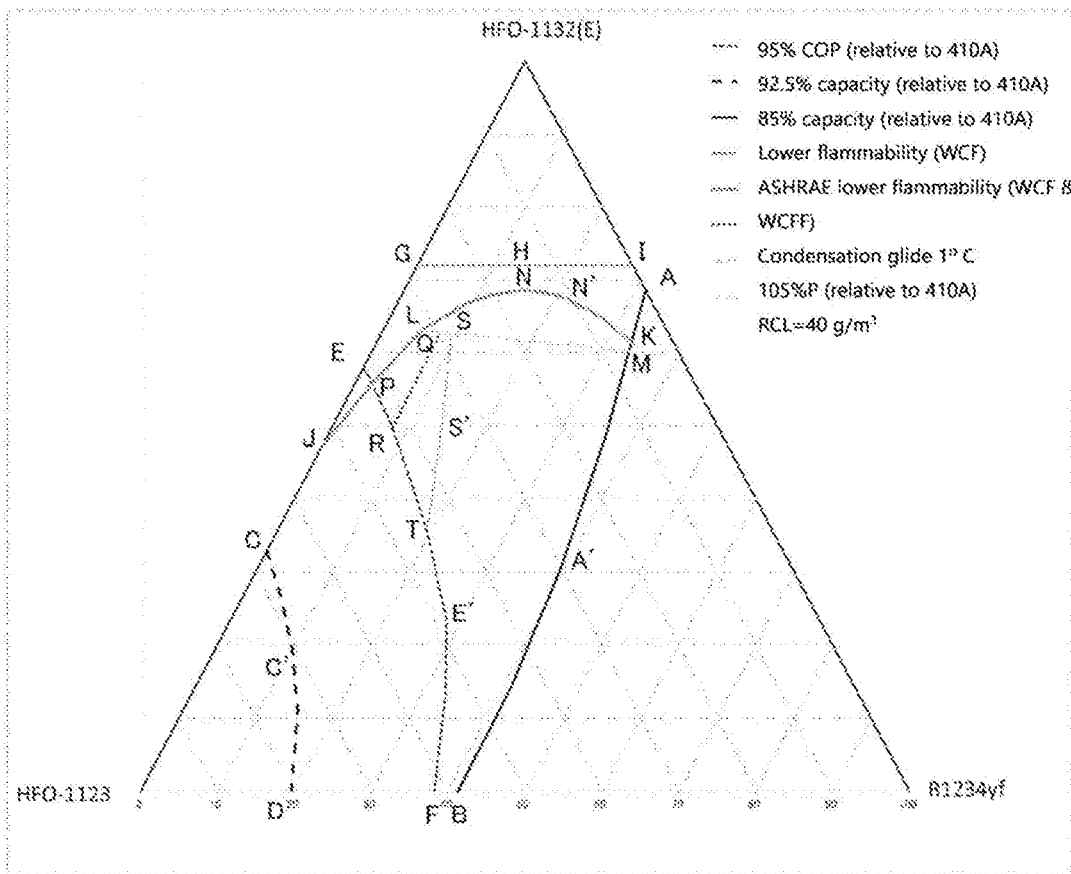


Fig.4

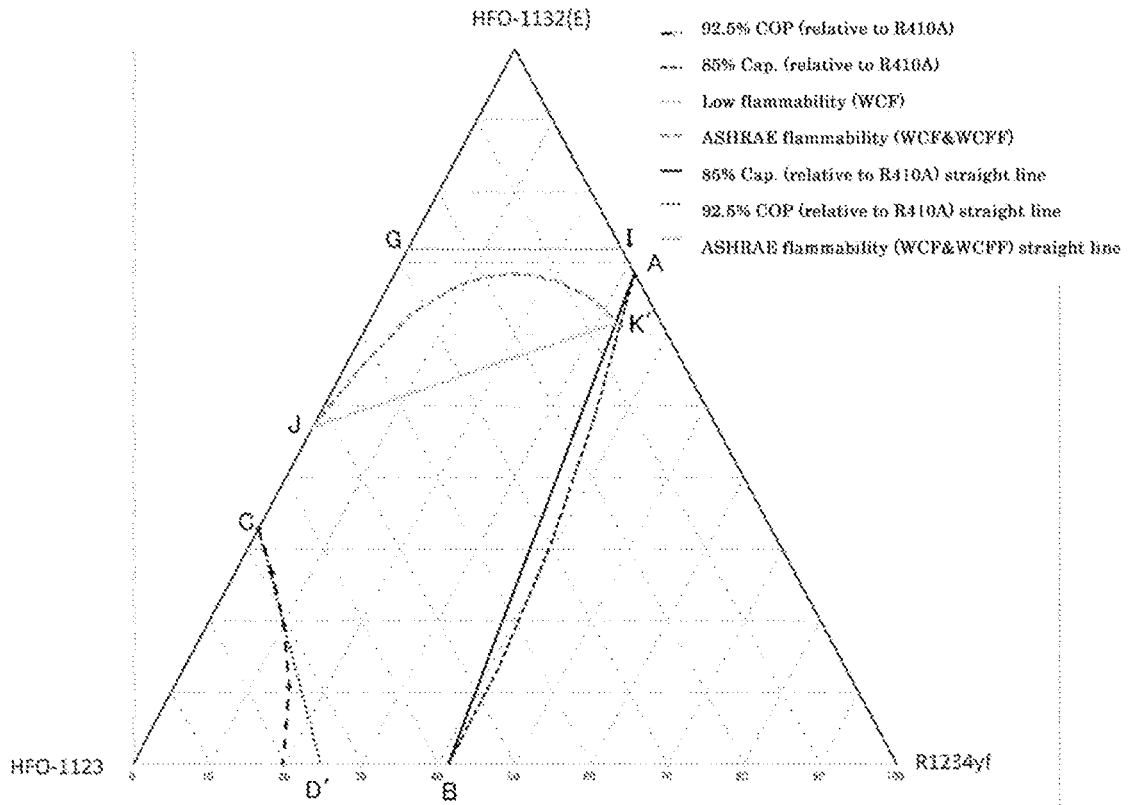


Fig. 5

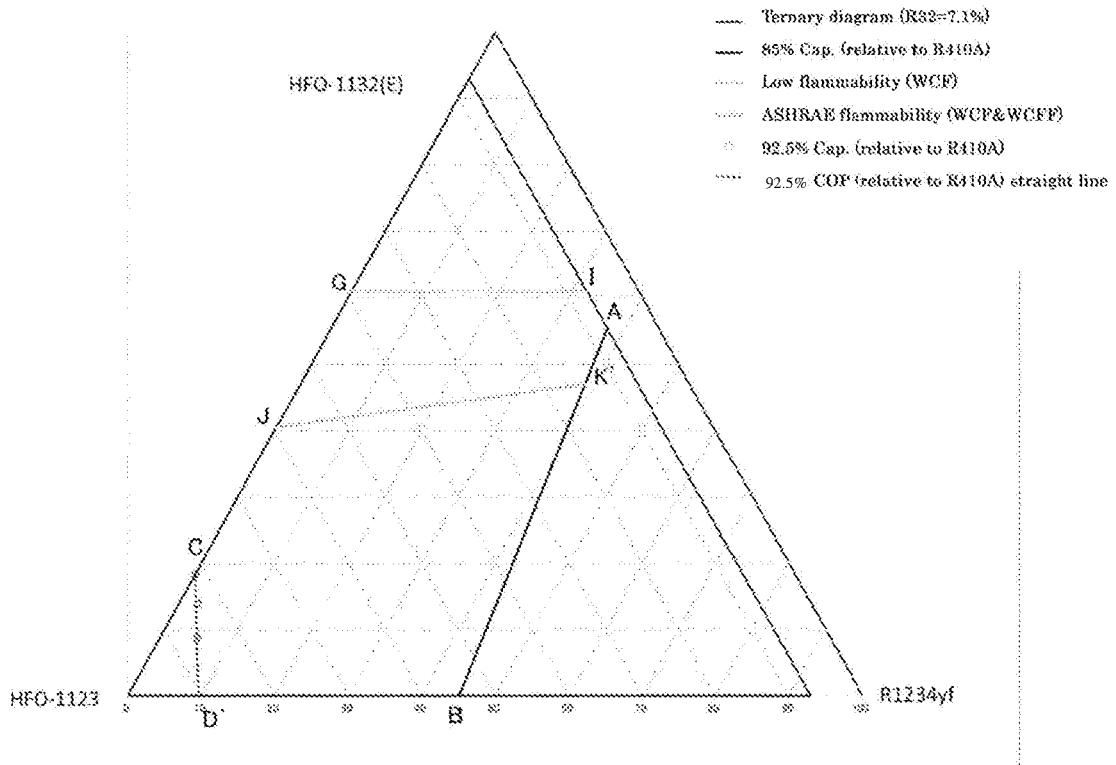


Fig. 6

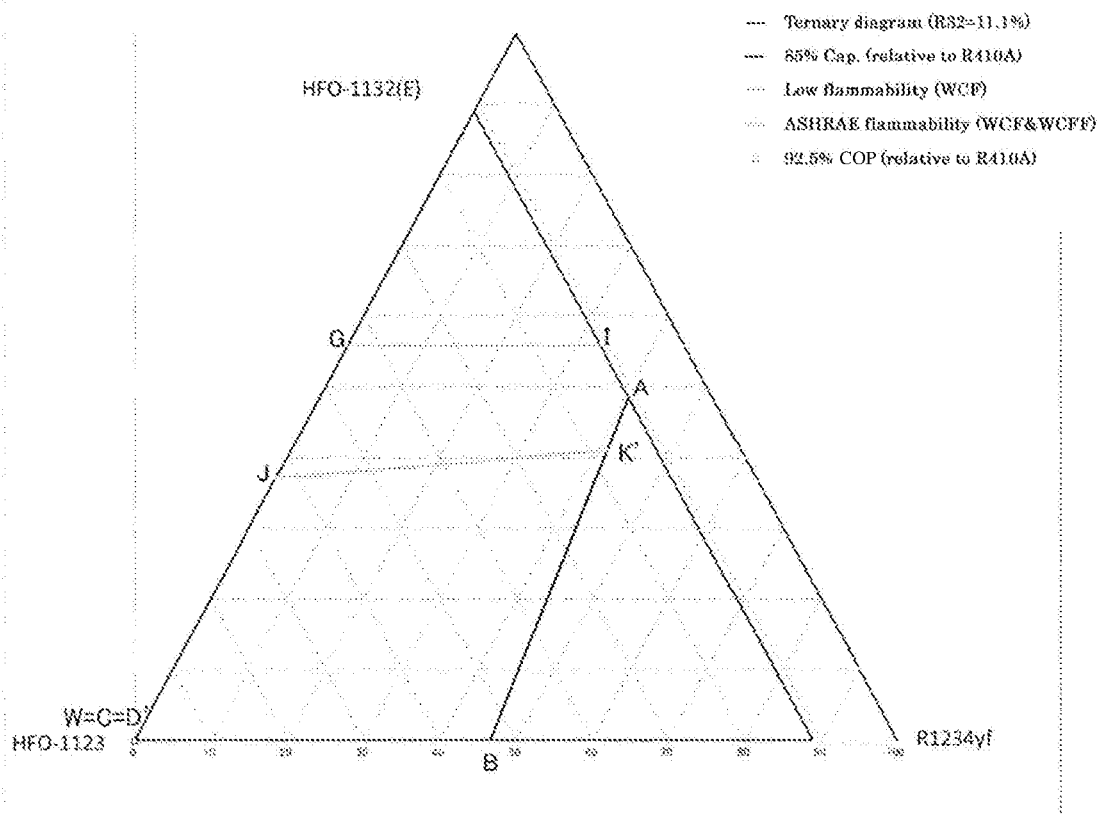


Fig. 7

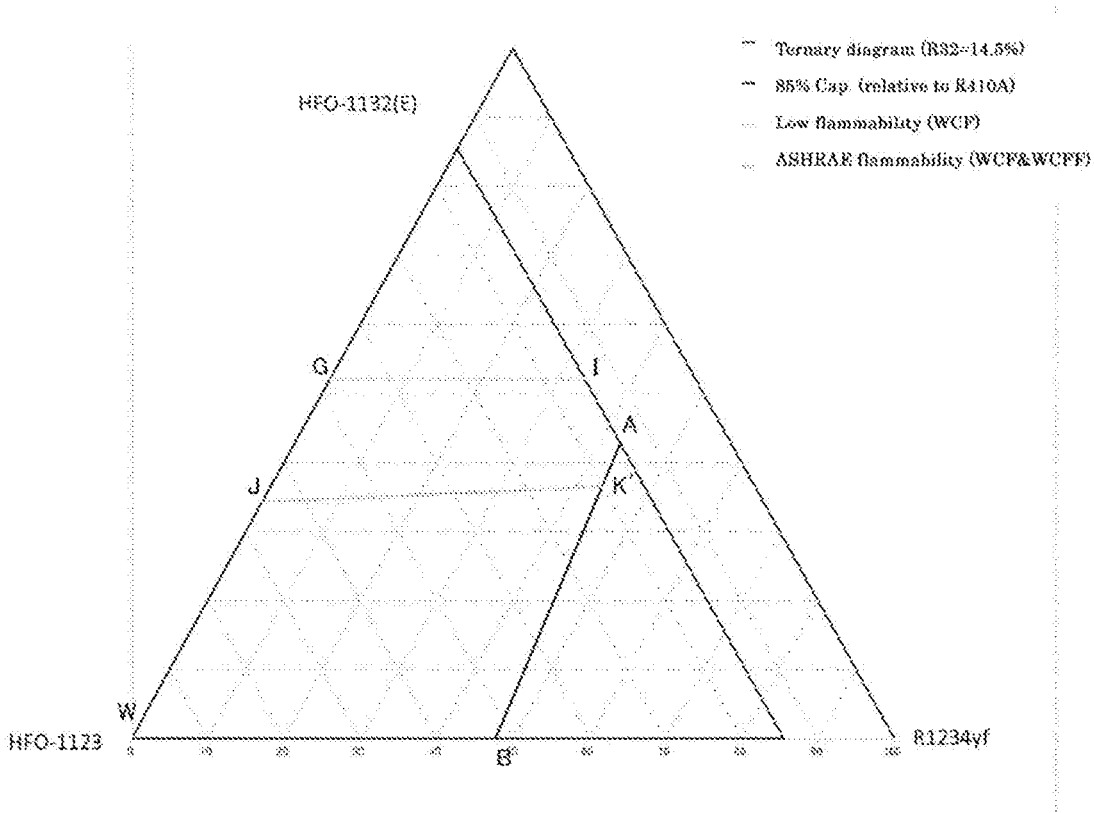


Fig. 8

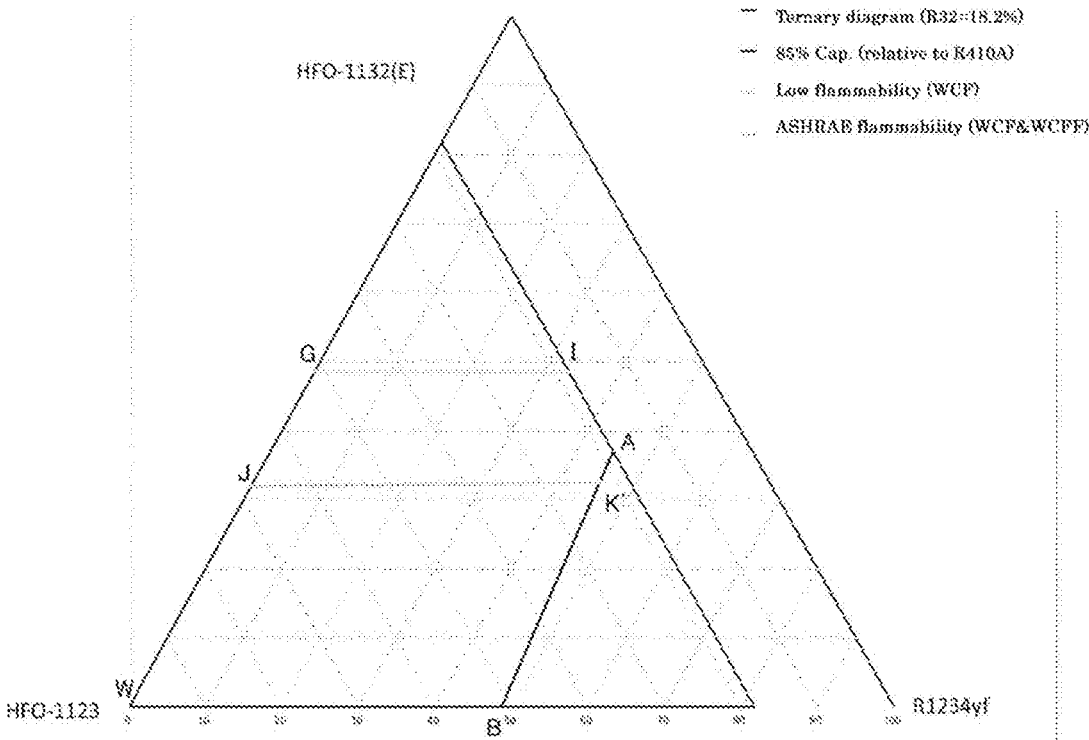


Fig. 9

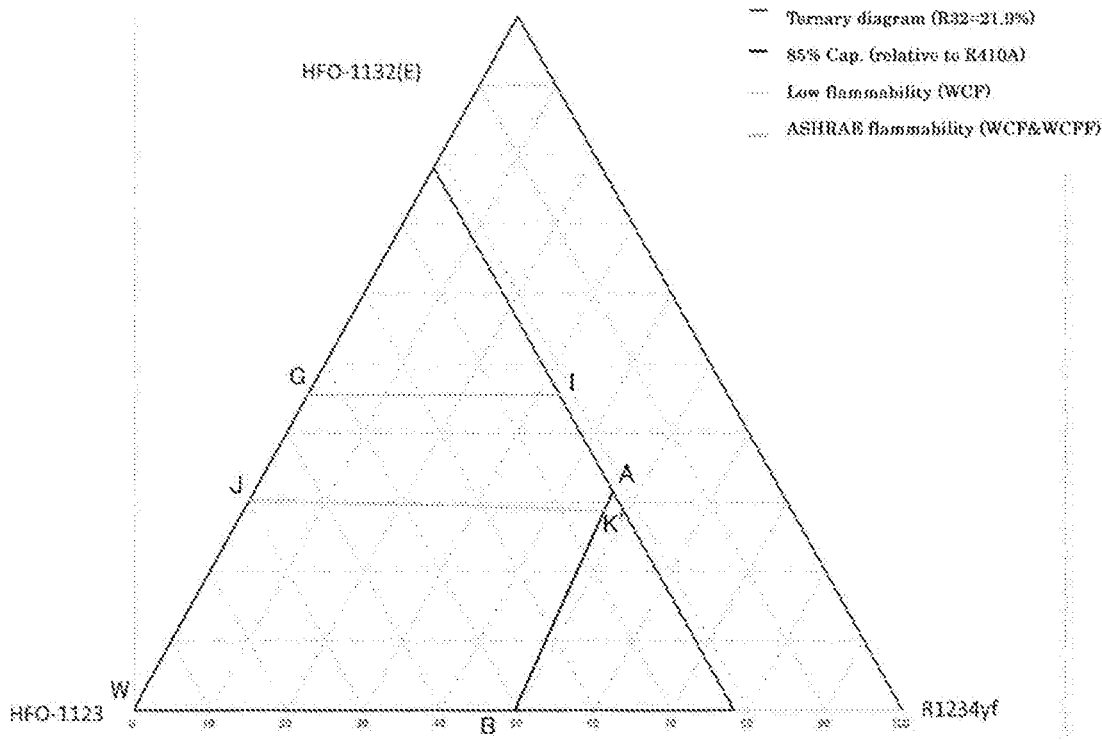


Fig. 10

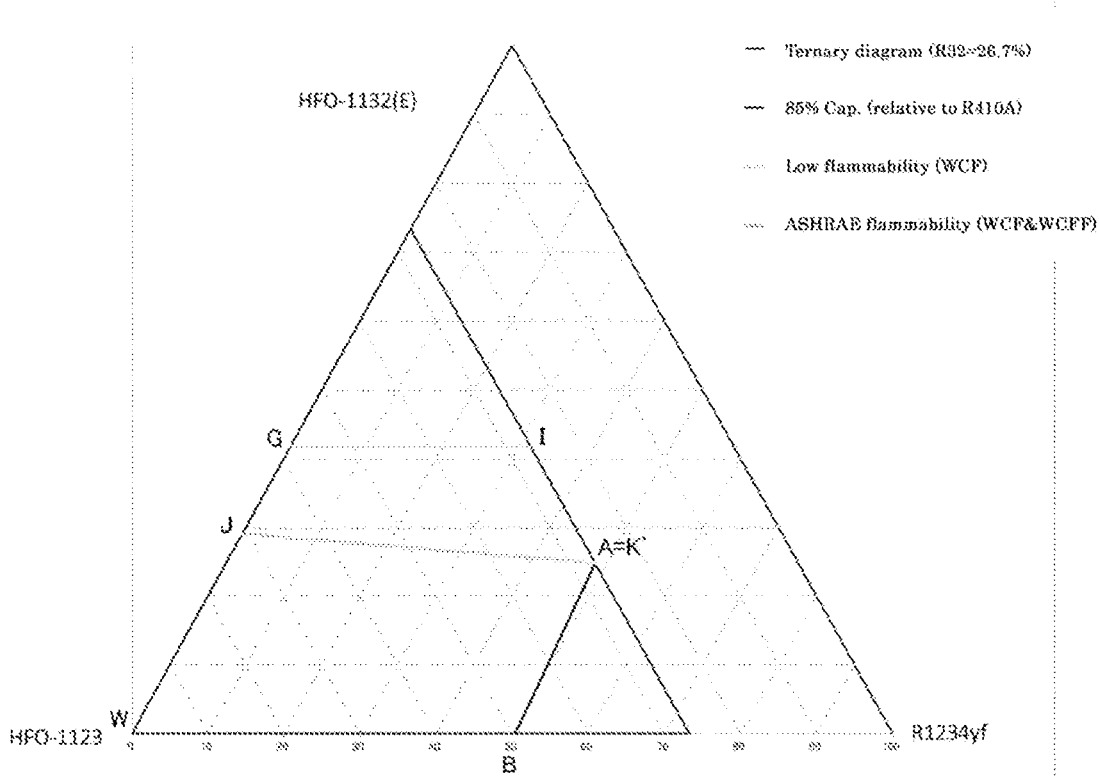


Fig. 11

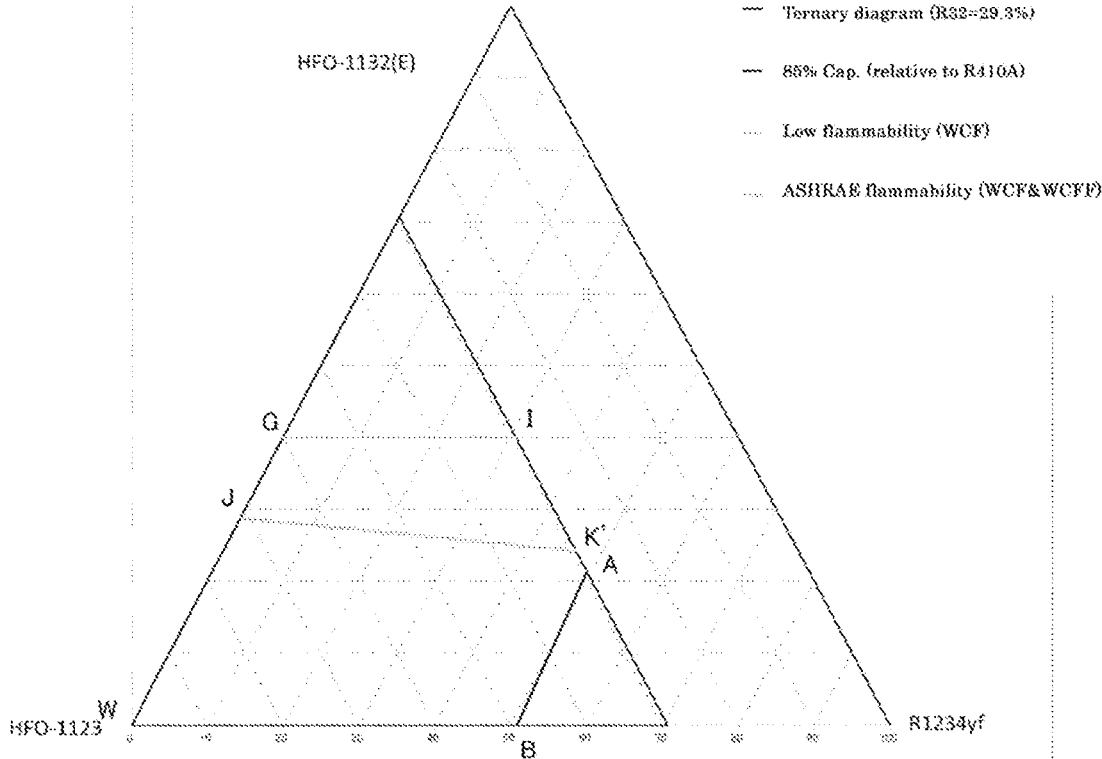


Fig. 12

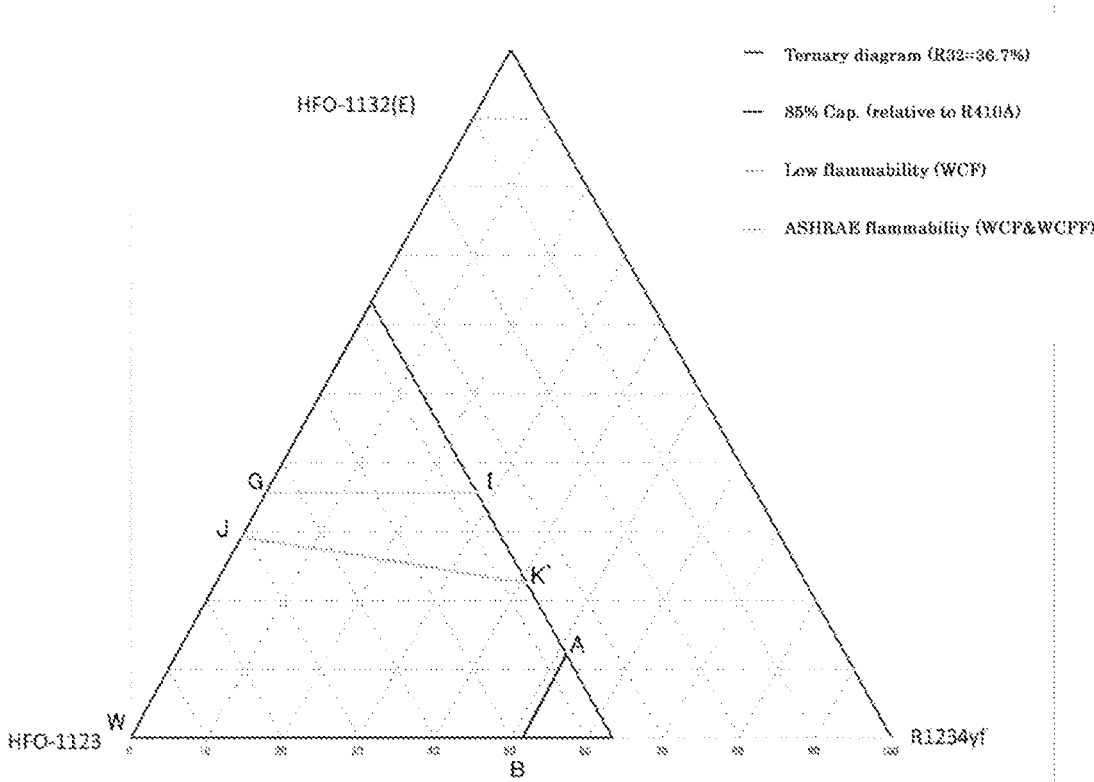


Fig. 13

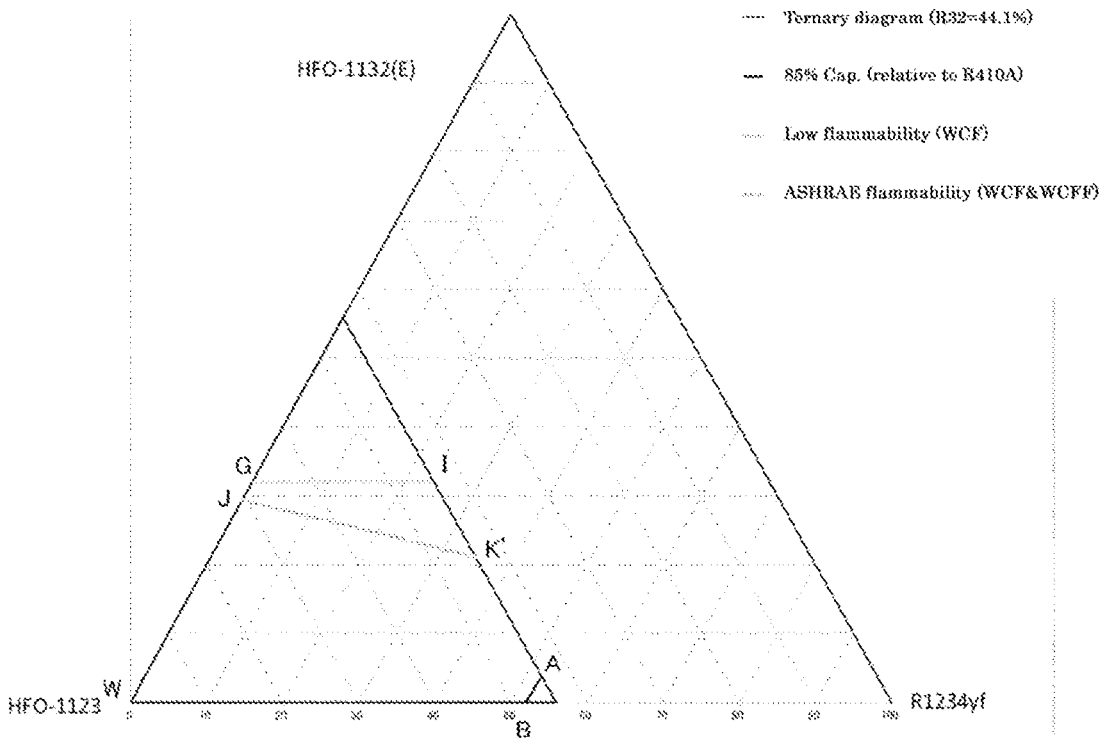


Fig. 14

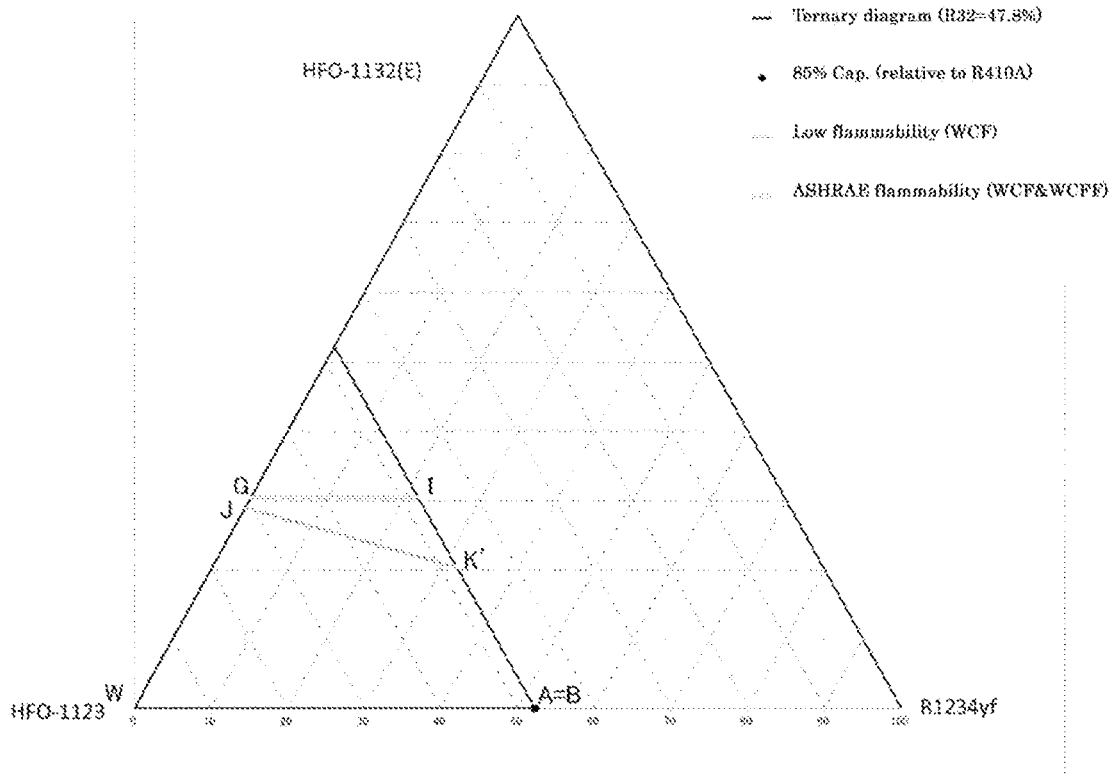


Fig. 15

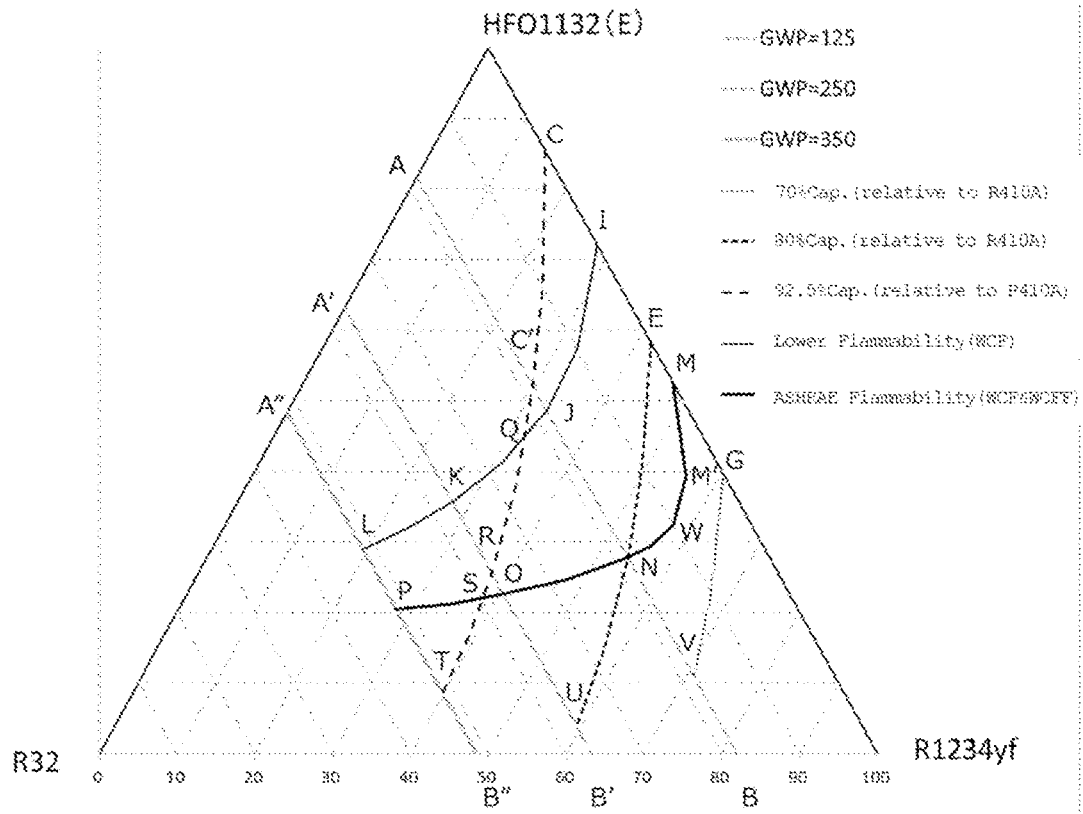
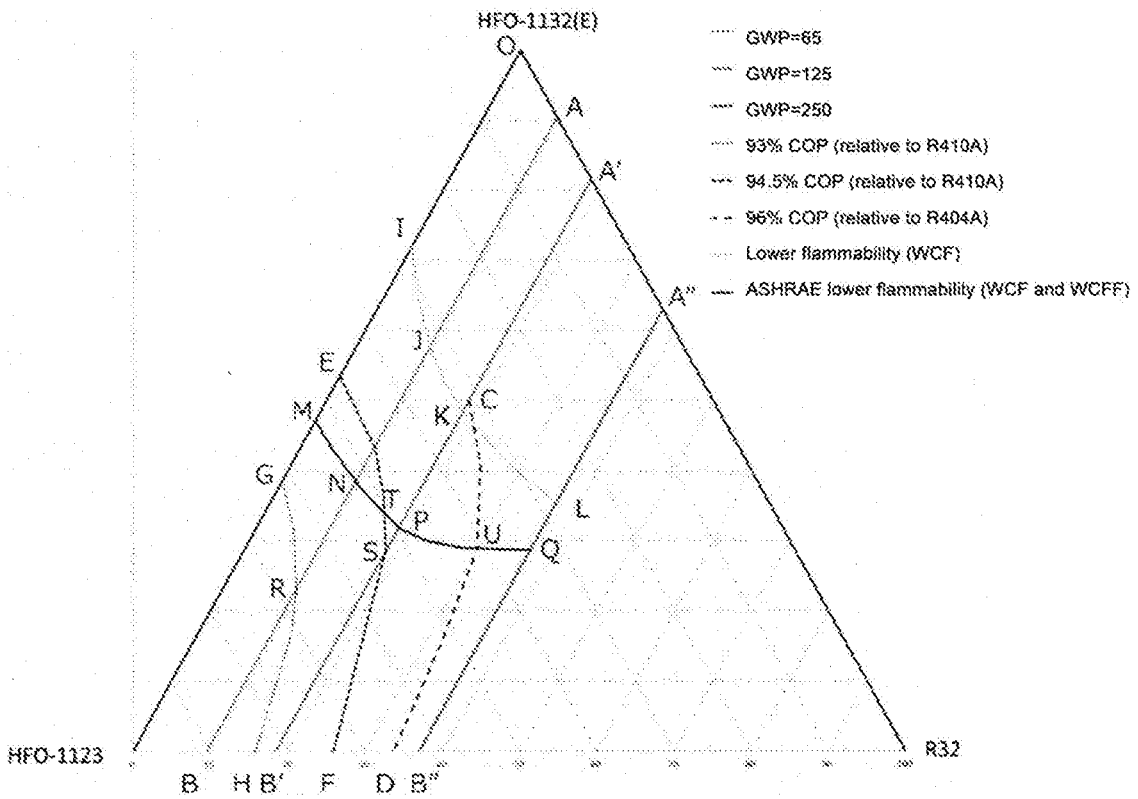


Fig. 16



**REFRIGERATING OIL FOR REFRIGERANT
OR REFRIGERANT COMPOSITION,
METHOD FOR USING REFRIGERATING
OIL, AND USE OF REFRIGERATING OIL**

TECHNICAL FIELD

[0001] The present disclosure relates to a refrigerating oil for refrigerants or refrigerant compositions, a method for using the refrigerating oil, and use of the refrigerating oil.

BACKGROUND ART

[0002] In the related art, R410A has been frequently used as a refrigerant in refrigeration cycle apparatuses such as air conditioners. R410A is a two-component mixed refrigerant of difluoromethane (CH_2F_2 ; HFC-32 or R32) and pentafluoroethane (C_2HF_5 ; HFC-125 or R125), which is a pseudo-azeotropic composition.

[0003] However, R410A has a global warming potential (GWP) of 2088. From the viewpoint of increasing concern for global warming, R32 having a lower GWP of 675 has been more frequently used in recent years.

[0004] Therefore, for example, PTL 1 (International Publication No. 2015/141678) proposes various low-GWP mixture refrigerants as alternatives to R410A.

SUMMARY OF THE INVENTION

Technical Problem

[0005] However, it has not been studied that good lubricity in a refrigeration cycle apparatus is achieved when a refrigeration cycle is performed using a refrigerant having a sufficiently low GWP.

[0006] In view of the foregoing, it is an object of the present disclosure to provide a refrigerating oil for refrigerants or refrigerant compositions in which good lubricity can be achieved when a refrigeration cycle is performed using a refrigerant having a sufficiently low GWP, a method for using the refrigerating oil, and use of the refrigerating oil.

Solution to Problem

[0007] A refrigerating oil for a refrigerant composition according to a first aspect is a refrigerating oil for a refrigerant composition containing a refrigerant, wherein the refrigerant includes any one of refrigerants A to E6 below:

[0008] a refrigerant A containing trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and 2,3,3,3-tetrafluoro-1-propene (R1234yf);

[0009] a refrigerant B1 containing trans-1,2-difluoroethylene (HFO-1132(E)) and trifluoroethylene (HFO-1123) in a total amount of 99.5 mass % or more relative to a whole amount of the refrigerant and containing HFO-1132(E) in an amount of 62.0 mass % to 72.0 mass % relative to a whole amount of the refrigerant;

[0010] a refrigerant B2 containing HFO-1132(E) and HFO-1123 in a total amount of 99.5 mass % or more relative to a whole amount of the refrigerant and containing HFO-1132(E) in an amount of 45.1 mass % to 47.1 mass % relative to a whole amount of the refrigerant;

[0011] a refrigerant C1 containing trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), 2,3,3,3-tetrafluoro-1-propene (R1234yf), and difluoromethane (R32), wherein when x, y, z, and a respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, the

R1234yf, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32, coordinates (x, y, z) are defined as follows in a ternary diagram in which a total content of the HFO-1132(E), the HFO-1123, and the R1234yf is (100-a) mass %:

[0012] when $0 < a \leq 11.1$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BD', D'C, and CG that each connect two of six points below or on the straight lines GI, AB, and D'C (except for on point G, point I, point A, point B, point D', and point C):

[0013] point G ($0.026a^2 - 1.7478a + 72.0$, $-0.026a^2 + 0.7478a + 28.0$, 0.0),

[0014] point I ($0.026a^2 - 1.7478a + 72.0$, 0.0, $-0.026a^2 + 0.7478a + 28.0$),

[0015] point A ($0.0134a^2 - 1.9681a + 68.6$, 0.0, $-0.0134a^2 + 0.9681a + 31.4$),

[0016] point B (0.0, $0.0144a^2 - 1.6377a + 58.7$, $-0.0144a^2 + 0.6377a + 41.3$),

[0017] point D' (0.0, $0.0224a^2 + 0.968a + 75.4$, $-0.0224a^2 - 1.968a + 24.6$), and

[0018] point C ($-0.2304a^2 - 0.4062a + 32.9$, $0.2304a^2 - 0.5938a + 67.1$, 0.0),

[0019] when $11.1 < a \leq 18.2$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

[0020] point G ($0.02a^2 - 1.6013a + 71.105$, $-0.02a^2 + 0.6013a + 28.895$, 0.0),

[0021] point I ($0.02a^2 - 1.6013a + 71.105$, 0.0, $-0.02a^2 + 0.6013a + 28.895$),

[0022] point A ($0.0112a^2 - 1.9337a + 68.484$, 0.0, $-0.0112a^2 + 0.9337a + 31.516$),

[0023] point B (0.0, $0.0075a^2 - 1.5156a + 58.199$, $-0.0075a^2 + 0.5156a + 41.801$), and

[0024] point W (0.0, 100.0-a, 0.0),

[0025] when $18.2 < a \leq 26.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

[0026] point G ($0.0135a^2 - 1.4068a + 69.727$, $-0.0135a^2 + 0.4068a + 30.273$, 0.0),

[0027] point I ($0.0135a^2 - 1.4068a + 69.727$, 0.0, $-0.0135a^2 + 0.4068a + 30.273$),

[0028] point A ($0.0107a^2 - 1.9142a + 68.305$, 0.0, $-0.0107a^2 + 0.9142a + 31.695$),

[0029] point B (0.0, $0.009a^2 - 1.6045a + 59.318$, $-0.009a^2 + 0.6045a + 40.682$), and

[0030] point W (0.0, 100.0-a, 0.0),

[0031] when $26.7 < a \leq 36.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

[0032] point G ($0.0111a^2 - 1.3152a + 68.986$, $-0.0111a^2 + 0.3152a + 31.014$, 0.0),

[0033] point I ($0.0111a^2 - 1.3152a + 68.986$, 0.0, $-0.0111a^2 + 0.3152a + 31.014$),

[0034] point A ($0.0103a^2 - 1.9225a + 68.793$, 0.0, $-0.0103a^2 + 0.9225a + 31.207$),

[0035] point B (0.0, $0.0046a^2 - 1.41a + 57.286$, $-0.0046a^2 + 0.41a + 42.714$), and

[0036] point W (0.0, 100.0-a, 0.0), and
[0037] when $36.7 < a \leq 46.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):
[0038] point G ($0.0061a^2 - 0.9918a + 63.902$, $-0.0061a^2 - 0.0082a + 36.098$, 0.0),
[0039] point I ($0.0061a^2 - 0.9918a + 63.902$, 0.0, $-0.0061a^2 - 0.0082a + 36.098$),
[0040] point A ($0.0085a^2 - 1.8102a + 67.1$, 0.0, $-0.0085a^2 + 0.8102a + 32.9$),
[0041] point B (0.0, $0.0012a^2 - 1.1659a + 52.95$, $-0.0012a^2 + 0.1659a + 47.05$), and
[0042] point W (0.0, 100.0-a, 0.0);
[0043] a refrigerant C2 containing trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), 2,3,3,3-tetrafluoro-1-propene (R1234yf), and difluoromethane (R32), wherein when x, y, z, and a respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32, coordinates (x, y, z) are defined as follows in a ternary diagram in which a total content of the HFO-1132(E), the HFO-1123, and the R1234yf is (100-a) mass %:
[0044] when $0 < a \leq 11.1$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BD', D'C, and CJ that each connect two of five points below or on the straight lines JK', K'B, and D'C (except for on point J, point B, point D', and point C):
[0045] point J ($0.0049a^2 - 0.9645a + 47.1$, $-0.0049a^2 - 0.0355a + 52.9$, 0.0),
[0046] point K' ($0.0514a^2 - 2.4353a + 61.7$, $-0.0323a^2 + 0.4122a + 5.9$, $-0.0191a^2 + 1.0231a + 32.4$),
[0047] point B (0.0, $0.0144a^2 - 1.6377a + 58.7$, $-0.0144a^2 + 0.6377a + 41.3$),
[0049] point D' (0.0, $0.0224a^2 + 0.968a + 75.4$, $-0.0224a^2 - 1.968a + 24.6$), and
[0050] point C ($-0.2304a^2 - 0.4062a + 32.9$, $0.2304a^2 - 0.5938a + 67.1$, 0.0),
[0051] when $11.1 < a \leq 18.2$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BW, and WJ that each connect two of four points below or on the straight lines JK' and K'B (except for on point J, point B, and point W):
[0052] point J ($0.0243a^2 - 1.4161a + 49.725$, $-0.0243a^2 + 0.4161a + 50.275$, 0.0),
[0053] point K' ($0.0341a^2 - 2.1977a + 61.187$, $-0.0236a^2 + 0.34a + 5.636$, $-0.0105a^2 + 0.8577a + 33.177$),
[0054] point B (0.0, $0.0075a^2 - 1.5156a + 58.199$, $-0.0075a^2 + 0.5156a + 41.801$), and point W (0.0, 100.0-a, 0.0),
[0055] when $18.2 < a \leq 26.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BW, and WJ that each connect two of four points below or on the straight lines JK' and K'B (except for on point J, point B, and point W):
[0056] point J ($0.0246a^2 - 1.4476a + 50.184$, $-0.0246a^2 + 0.4476a + 49.816$, 0.0),
[0057] point K' ($0.0196a^2 - 1.7863a + 58.515$, $-0.0079a^2 - 0.1136a + 8.702$, $-0.0117a^2 + 0.8999a + 32.783$),
[0058] point B (0.0, $0.009a^2 - 1.6045a + 59.318$, $-0.009a^2 + 0.6045a + 40.682$), and

[0060] point W (0.0, 100.0-a, 0.0),
[0061] when $26.7 < a \leq 36.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'A, AB, BW, and WJ that each connect two of five points below or on the straight lines JK', K'A, and AB (except for on point J, point B, and point W):
[0062] point J ($0.0183a^2 - 1.1399a + 46.493$, $-0.0183a^2 + 0.1399a + 53.507$, 0.0),
[0063] point K' ($-0.0051a^2 + 0.0929a + 25.95$, 0.0, $0.0051a^2 - 1.0929a + 74.05$),
[0064] point A ($0.0103a^2 - 1.9225a + 68.793$, 0.0, $-0.0103a^2 + 0.9225a + 31.207$),
[0065] point B (0.0, $0.0046a^2 - 1.41a + 57.286$, $-0.0046a^2 + 0.41a + 42.714$), and
[0066] point W (0.0, 100.0-a, 0.0), and
[0067] when $36.7 < a \leq 46.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'A, AB, BW, and WJ that each connect two of five points below or on the straight lines JK', K'A, and AB (except for on point J, point B, and point W):
[0068] point J ($-0.0134a^2 + 1.0956a + 7.13$, $0.0134a^2 - 2.0956a + 92.87$, 0.0),
[0069] point K' ($-1.892a + 29.443$, 0.0, $0.892a + 70.557$),
[0070] point A ($0.0085a^2 - 1.8102a + 67.1$, 0.0, $-0.0085a^2 + 0.8102a + 32.9$),
[0071] point B (0.0, $0.0012a^2 - 1.1659a + 52.95$, $-0.0012a^2 + 0.1659a + 47.05$), and
[0072] point W (0.0, 100.0-a, 0.0);
[0073] a refrigerant D1 containing trans-1,2-difluoroethylene (HFO-1132(E)), difluoromethane (R32), and 2,3,3,3-tetrafluoro-1-propene (R1234yf), wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments IJ, JN, NE, and EI that each connect two of four points below or on the line segments (except for a point on the line segment EI) in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:
[0074] point I (72.0, 0.0, 28.0),
[0075] point J (48.5, 18.3, 33.2),
[0076] point N (27.7, 18.2, 54.1), and
[0077] point E (58.3, 0.0, 41.7),
[0078] the line segment IJ is represented by coordinates ($0.0236y^2 - 1.7616y + 72.0$, y, $-0.0236y^2 + 0.7616y + 28.0$),
[0079] the line segment NE is represented by coordinates ($0.012y^2 - 1.9003y + 58.3$, y, $-0.012y^2 + 0.9003y + 41.7$), and
[0080] the line segments JN and EI are straight lines;
[0081] a refrigerant D2 containing HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments MM', M'N, NV, VG, and GM that each connect two of five points below or on the line segments (except for a point on the line segment GM) in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:
[0082] point M (52.6, 0.0, 47.4),
[0083] point M' (39.2, 5.0, 55.8),
[0084] point N (27.7, 18.2, 54.1),
[0085] point V (11.0, 18.1, 70.9), and
[0086] point G (39.6, 0.0, 60.4),

[0087] the line segment MM' is represented by coordinates $(0.132y^2 - 3.34y + 52.6, y, -0.132y^2 + 2.34y + 47.4)$,

[0088] the line segment M'N is represented by coordinates $(0.0596y^2 - 2.2541y + 48.98, y, -0.0596y^2 + 1.2541y + 51.02)$,

[0089] the line segment VG is represented by coordinates $(0.0123y^2 - 1.8033y + 39.6, y, -0.0123y^2 + 0.8033y + 60.4)$, and

[0090] the line segments NV and GM are straight lines;

[0091] a refrigerant D3 containing HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments ON, NU, and UO that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

[0092] point O (22.6, 36.8, 40.6),

[0093] point N (27.7, 18.2, 54.1), and

[0094] point U (3.9, 36.7, 59.4),

[0095] the line segment ON is represented by coordinates $(0.0072y^2 - 0.6701y + 37.512, y, -0.0072y^2 - 0.3299y + 62.488)$,

[0096] the line segment NU is represented by coordinates $(0.0083y^2 - 1.7403y + 56.635, y, -0.0083y^2 + 0.7403y + 43.365)$, and

[0097] the line segment UO is a straight line;

[0098] a refrigerant D4 containing HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments QR, RT, TL, LK, and KQ that each connect two of five points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

[0099] point Q (44.6, 23.0, 32.4),

[0100] point R (25.5, 36.8, 37.7),

[0101] point T (8.6, 51.6, 39.8),

[0102] point L (28.9, 51.7, 19.4), and

[0103] point K (35.6, 36.8, 27.6),

[0104] the line segment QR is represented by coordinates $(0.0099y^2 - 1.975y + 84.765, y, -0.0099y^2 + 0.975y + 15.235)$,

[0105] the line segment RT is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$,

[0106] the line segment LK is represented by coordinates $(0.0049y^2 - 0.8842y + 61.488, y, -0.0049y^2 - 0.1158y + 38.512)$,

[0107] the line segment KQ is represented by coordinates $(0.0095y^2 - 1.2222y + 67.676, y, -0.0095y^2 + 0.2222y + 32.324)$, and

[0108] the line segment TL is a straight line;

[0109] a refrigerant D5 containing HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments PS, ST, and TP that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

[0110] point P (20.5, 51.7, 27.8),

[0111] point S (21.9, 39.7, 38.4), and

[0112] point T (8.6, 51.6, 39.8),

[0113] the line segment PS is represented by coordinates $(0.0064y^2 - 0.7103y + 40.1, y, -0.0064y^2 - 0.2897y + 59.9)$,

[0114] the line segment ST is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$, and

[0115] the line segment TP is a straight line;

[0116] a refrigerant E1 containing trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and difluoromethane (R32), wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments IK, KB', B'H, HR, RG, and GI that each connect two of six points below or on the line segments (except for points on the line segments B'H and GI) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

[0117] point I (72.0, 28.0, 0.0),

[0118] point K (48.4, 33.2, 18.4),

[0119] point B' (0.0, 81.6, 18.4),

[0120] point H (0.0, 84.2, 15.8),

[0121] point R (23.1, 67.4, 9.5), and

[0122] point G (38.5, 61.5, 0.0),

[0123] the line segment IK is represented by coordinates $(0.025z^2 - 1.7429z + 72.00, -0.025z^2 + 0.7429z + 28.0, z)$,

[0124] the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$,

[0125] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

[0126] the line segments KB' and GI are straight lines;

[0127] a refrigerant E2 containing HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments IJ, JR, RG, and GI that each connect two of four points below or on the line segments (except for a point on the line segment GI) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

[0128] point I (72.0, 28.0, 0.0),

[0129] point J (57.7, 32.8, 9.5),

[0130] point R (23.1, 67.4, 9.5), and

[0131] point G (38.5, 61.5, 0.0),

[0132] the line segment IJ is represented by coordinates $(0.025z^2 - 1.7429z + 72.0, -0.025z^2 + 0.7429z + 28.0, z)$,

[0133] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

[0134] the line segments JR and GI are straight lines;

[0135] a refrigerant E3 containing HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments MP, PB', B'H, HR, RG, and GM that each connect two of six points below or on the line segments (except for points on the line segments B'H and GM) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

- [0136] point M (47.1, 52.9, 0.0),
 [0137] point P (31.8, 49.8, 18.4),
 [0138] point B' (0.0, 81.6, 18.4),
 [0139] point H (0.0, 84.2, 15.8),
 [0140] point R (23.1, 67.4, 9.5), and
 [0141] point G (38.5, 61.5, 0.0),
 [0142] the line segment MP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,
 [0143] the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$,
 [0144] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and
 [0145] the line segments PB' and GM are straight lines;
 [0146] a refrigerant E4 containing HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments MN, NR, RG, and GM that each connect two of four points below or on the line segments (except for a point on the line segment GM) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:
 [0147] point M (47.1, 52.9, 0.0),
 [0148] point N (38.5, 52.1, 9.5),
 [0149] point R (23.1, 67.4, 9.5), and
 [0150] point G (38.5, 61.5, 0.0),
 [0151] the line segment MN is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,
 [0152] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and
 [0153] the line segments JR and GI are straight lines;
 [0154] a refrigerant E5 containing HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments PS, ST, and TP that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:
 [0155] point P (31.8, 49.8, 18.4),
 [0156] point S (25.4, 56.2, 18.4), and
 [0157] point T (34.8, 51.0, 14.2),
 [0158] the line segment ST is represented by coordinates $(-0.0982z^2 + 0.9622z + 40.931, 0.0982z^2 - 1.9622z + 59.069, z)$,
 [0159] the line segment TP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$, and
 [0160] the line segment PS is a straight line; and
 [0161] a refrigerant E6 containing HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments QB', B'D, DU, and UQ that each connect two of four points below or on the line segments (except for a point on the line segment B'D) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:
 [0162] point Q (28.6, 34.4, 37.0),
 [0163] point B' (0.0, 63.0, 37.0),
 [0164] point D (0.0, 67.0, 33.0), and
 [0165] point U (28.7, 41.2, 30.1),
 [0166] the line segment DU is represented by coordinates $(-3.4962z^2 + 210.71z - 3146.1, 3.4962z^2 - 211.71z + 3246.1, z)$,
 [0167] the line segment UQ is represented by coordinates $(0.0135z^2 - 0.9181z + 44.133, -0.0135z^2 - 0.0819z + 55.867, z)$, and
 [0168] the line segments QB' and B'D are straight lines.
 [0169] In the case where the refrigerant is the refrigerant A, the refrigerant is preferably any one of refrigerants A1 to A7 below:
 [0170] a refrigerant A1 in which when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R1234yf relative to a total content of the HFO-1132(E), the HFO-1123, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments AA', A'B, BD, DC', C'C, CO, and OA that each connect two of seven points below or on the line segments (except for points on the line segments BD, CO, and OA) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R1234yf is 100 mass %:
 [0171] point A (68.6, 0.0, 31.4),
 [0172] point A' (30.6, 30.0, 39.4),
 [0173] point B (0.0, 58.7, 41.3),
 [0174] point D (0.0, 80.4, 19.6),
 [0175] point C' (19.5, 70.5, 10.0),
 [0176] point C (32.9, 67.1, 0.0), and
 [0177] point O (100.0, 0.0, 0.0),
 [0178] the line segment AA' is represented by coordinates $(x, 0.0016x^2 - 0.9473x + 57.497, -0.0016x^2 - 0.0527x + 42.503)$,
 [0179] the line segment A'B is represented by coordinates $(x, 0.0029x^2 - 1.0268x + 58.7, -0.0029x^2 + 0.0268x + 41.3)$,
 [0180] the line segment DC' is represented by coordinates $(x, 0.0082x^2 - 0.6671x + 80.4, -0.0082x^2 - 0.3329x + 19.6)$,
 [0181] the line segment C'C is represented by coordinates $(x, 0.0067x^2 - 0.6034x + 79.729, -0.0067x^2 - 0.3966x + 20.271)$, and
 [0182] the line segments BD, CO, and OA are straight lines;
 [0183] a refrigerant A2 in which when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R1234yf relative to a total content of the HFO-1132(E), the HFO-1123, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments GI, IA, AA', A'B, BD, DC', C'C, and CG that each connect two of eight points below or on the line segments (except for points on the line segments IA, BD, and CG) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R1234yf is 100 mass %:
 [0184] point G (72.0, 28.0, 0.0),
 [0185] point I (72.0, 0.0, 28.0),
 [0186] point A (68.6, 0.0, 31.4),
 [0187] point A' (30.6, 30.0, 39.4),
 [0188] point B (0.0, 58.7, 41.3),
 [0189] point D (0.0, 80.4, 19.6),
 [0190] point C' (19.5, 70.5, 10.0), and
 [0191] point C (32.9, 67.1, 0.0),
 [0192] the line segment AA' is represented by coordinates $(x, 0.0016x^2 - 0.9473x + 57.497, -0.0016x^2 - 0.0527x + 42.503)$,

[0193] the line segment A'B is represented by coordinates $(x, 0.0029x^2 - 1.0268x + 58.7, -0.0029x^2 + 0.0268x + 41.3)$,

[0194] the line segment DC' is represented by coordinates $(x, 0.0082x^2 - 0.6671x + 80.4, -0.0082x^2 - 0.3329x + 19.6)$,

[0195] the line segment C'C is represented by coordinates $(x, 0.0067x^2 - 0.6034x + 79.729, -0.0067x^2 - 0.3966x + 20.271)$, and

[0196] the line segments GI, IA, BD, and CG are straight lines;

[0197] a refrigerant A3 in which when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R1234yf relative to a total content of the HFO-1132(E), the HFO-1123, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments JP, PN, NK, KA', A'B, BD, DC', C'C, and CJ that each connect two of nine points below or on the line segments (except for points on the line segments BD and CJ) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R1234yf is 100 mass %:

[0198] point J (47.1, 52.9, 0.0),

[0199] point P (55.8, 42.0, 2.2),

[0200] point N (68.6, 16.3, 15.1),

[0201] point K (61.3, 5.4, 33.3),

[0202] point A' (30.6, 30.0, 39.4),

[0203] point B (0.0, 58.7, 41.3),

[0204] point D (0.0, 80.4, 19.6),

[0205] point C' (19.5, 70.5, 10.0), and

[0206] point C (32.9, 67.1, 0.0),

[0207] the line segment PN is represented by coordinates $(x, -0.1135x^2 + 12.112x - 280.43, 0.1135x^2 - 13.112x + 380.43)$,

[0208] the line segment NK is represented by coordinates $(x, 0.2421x^2 - 29.955x + 931.91, -0.2421x^2 + 28.955x - 831.91)$,

[0209] the line segment KA' is represented by coordinates $(x, 0.0016x^2 - 0.9473x + 57.497, -0.0016x^2 - 0.0527x + 42.503)$,

[0210] the line segment A'B is represented by coordinates $(x, 0.0029x^2 - 1.0268x + 58.7, -0.0029x^2 + 0.0268x + 41.3)$,

[0211] the line segment DC' is represented by coordinates $(x, 0.0082x^2 - 0.6671x + 80.4, -0.0082x^2 - 0.3329x + 19.6)$,

[0212] the line segment C'C is represented by coordinates $(x, 0.0067x^2 - 0.6034x + 79.729, -0.0067x^2 - 0.3966x + 20.271)$, and

[0213] the line segments JP, BD, and CG are straight lines;

[0214] a refrigerant A4 in which when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R1234yf relative to a total content of the HFO-1132(E), the HFO-1123, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments JP, PL, LM, MA', A'B, BD, DC', C'C, and CJ that each connect two of nine points below or on the line segments (except for points on the line segments BD and CJ) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R1234yf is 100 mass %:

[0215] point J (47.1, 52.9, 0.0),

[0216] point P (55.8, 42.0, 2.2),

[0217] point L (63.1, 31.9, 5.0),

[0218] point M (60.3, 6.2, 33.5),

[0219] point A' (30.6, 30.0, 39.4),

[0220] point B (0.0, 58.7, 41.3),

[0221] point D (0.0, 80.4, 19.6),

[0222] point C' (19.5, 70.5, 10.0), and

[0223] point C (32.9, 67.1, 0.0),

[0224] the line segment PL is represented by coordinates $(x, -0.1135x^2 + 12.112x - 280.43, 0.1135x^2 - 13.112x + 380.43)$,

[0225] the line segment MA' is represented by coordinates $(x, 0.0016x^2 - 0.9473x + 57.497, -0.0016x^2 - 0.0527x + 42.503)$,

[0226] the line segment A'B is represented by coordinates $(x, 0.0029x^2 - 1.0268x + 58.7, -0.0029x^2 + 0.0268x + 41.3)$,

[0227] the line segment DC' is represented by coordinates $(x, 0.0082x^2 - 0.6671x + 80.4, -0.0082x^2 - 0.3329x + 19.6)$,

[0228] the line segment C'C is represented by coordinates $(x, 0.0067x^2 - 0.6034x + 79.729, -0.0067x^2 - 0.3966x + 20.271)$, and

[0229] the line segments JP, LM, BD, and CG are straight lines;

[0230] a refrigerant A5 in which when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R1234yf relative to a total content of the HFO-1132(E), the HFO-1123, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments PL, LM, MA', A'B, BF, FT, and TP that each connect two of seven points below or on the line segments (except for a point on the line segment BF) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R1234yf is 100 mass %:

[0231] point P (55.8, 42.0, 2.2),

[0232] point L (63.1, 31.9, 5.0),

[0233] point M (60.3, 6.2, 33.5),

[0234] point A' (30.6, 30.0, 39.4),

[0235] point B (0.0, 58.7, 41.3),

[0236] point F (0.0, 61.8, 38.2), and

[0237] point T (35.8, 44.9, 19.3),

[0238] the line segment PL is represented by coordinates $(x, -0.1135x^2 + 12.112x - 280.43, 0.1135x^2 - 13.112x + 380.43)$,

[0239] the line segment MA' is represented by coordinates $(x, 0.0016x^2 - 0.9473x + 57.497, -0.0016x^2 - 0.0527x + 42.503)$,

[0240] the line segment A'B is represented by coordinates $(x, 0.0029x^2 - 1.0268x + 58.7, -0.0029x^2 + 0.0268x + 41.3)$,

[0241] the line segment FT is represented by coordinates $(x, 0.0078x^2 - 0.7501x + 61.8, -0.0078x^2 - 0.2499x + 38.2)$,

[0242] the line segment TP is represented by coordinates $(x, 0.00672x^2 - 0.7607x + 63.525, -0.00672x^2 - 0.2393x + 36.475)$, and

[0243] the line segments LM and BF are straight lines;

[0244] a refrigerant A6 in which when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R1234yf relative to a total content of the HFO-1132(E), the HFO-1123, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments PL, LQ, QR, and RP that each connect two of four points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R1234yf is 100 mass %:

[0245] point P (55.8, 42.0, 2.2),

[0246] point L (63.1, 31.9, 5.0),

[0247] point Q (62.8, 29.6, 7.6), and

[0248] point R (49.8, 42.3, 7.9),

[0249] the line segment PL is represented by coordinates $(x, -0.1135x^2 + 12.112x - 280.43, 0.1135x^2 - 13.112x + 380.43)$,

[0250] the line segment RP is represented by coordinates $(x, 0.00672x^2 - 0.7607x + 63.525, -0.00672x^2 - 0.2393x + 36.475)$, and

[0251] the line segments LQ and QR are straight lines; and

[0252] a refrigerant A7 in which when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R1234yf relative to a total content of the HFO-1132(E), the HFO-1123, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments SM, MA', A'B, BF, FT, and TS that each connect two of six points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R1234yf is 100 mass %:

[0253] point S (62.6, 28.3, 9.1),

[0254] point M (60.3, 6.2, 33.5),

[0255] point A' (30.6, 30.0, 39.4),

[0256] point B (0.0, 58.7, 41.3),

[0257] point F (0.0, 61.8, 38.2), and

[0258] point T (35.8, 44.9, 19.3),

[0259] the line segment MA' is represented by coordinates $(x, 0.0016x^2 - 0.9473x + 57.497, -0.0016x^2 - 0.0527x + 42.503)$,

[0260] the line segment A'B is represented by coordinates $(x, 0.0029x^2 - 1.0268x + 58.7, -0.0029x^2 + 0.0268x + 41.3)$,

[0261] the line segment FT is represented by coordinates $(x, 0.0078x^2 - 0.7501x + 61.8, -0.0078x^2 - 0.2499x + 38.2)$,

[0262] the line segment TS is represented by coordinates $(x, -0.0017x^2 - 0.7869x + 70.888, -0.0017x^2 - 0.2131x + 29.112)$, and

[0263] the line segments SM and BF are straight lines.

[0264] In this refrigerating oil for a refrigerant composition, good lubricity can be achieved when a refrigeration cycle is performed using a refrigerant having a sufficiently low GWP or a refrigerant composition containing the refrigerant.

[0265] In the refrigerating oil for a refrigerant composition in which the refrigerant is the refrigerant A, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) and a coefficient of performance (COP) equal to those of R410A is used.

[0266] In the refrigerating oil for a refrigerant composition in which the refrigerant is the refrigerant B1 or the refrigerant B2, good lubricity can also be achieved when a refrigerant having a coefficient of performance (COP) and a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) equal to those of R410A and classified with lower flammability (Class 2L) in the standard of The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is used.

[0267] In the refrigerating oil for a refrigerant composition in which the refrigerant is the refrigerant C1 or the refrigerant C2, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) and a coefficient of performance (COP) equal to those of R410A is used.

[0268] In the refrigerating oil for a refrigerant composition in which the refrigerant is any one of the refrigerants D1 to D5, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) equal to that of R410A and classified with lower flammability (Class 2L) in the standard

of The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is used.

[0269] In the refrigerating oil for a refrigerant composition in which the refrigerant is any one of the refrigerants E1 to E6, good lubricity can also be achieved when a refrigerant having a coefficient of performance (COP) equal to that of R410A is used.

[0270] A refrigerating oil for a refrigerant composition according to a second aspect is the refrigerating oil for a refrigerant composition according to the first aspect, wherein the refrigerating oil has a kinematic viscosity at 40° C. of 1 mm²/s or more and 750 mm²/s or less.

[0271] A refrigerating oil for a refrigerant composition according to a third aspect is the refrigerating oil for a refrigerant composition according to the first aspect or the second aspect, wherein the refrigerating oil has a kinematic viscosity at 100° C. of 1 mm²/s or more and 100 mm²/s or less.

[0272] A refrigerating oil for a refrigerant composition according to a fourth aspect is the refrigerating oil for a refrigerant composition according to any one of the first aspect to the third aspect, wherein the refrigerating oil has a volume resistivity at 25° C. of 1.0×10^{12} Ω·cm or more.

[0273] A refrigerating oil for a refrigerant composition according to a fifth aspect is the refrigerating oil for a refrigerant composition according to any one of the first aspect to the fourth aspect, wherein the refrigerating oil has an acid number of 0.1 mgKOH/g or less.

[0274] A refrigerating oil for a refrigerant composition according to a sixth aspect is the refrigerating oil for a refrigerant composition according to any one of the first aspect to the fifth aspect, wherein the refrigerating oil has an ash content of 100 ppm or less.

[0275] A refrigerating oil for a refrigerant composition according to a seventh aspect is the refrigerating oil for a refrigerant composition according to any one of the first aspect to the sixth aspect, wherein the refrigerating oil has an aniline point of -100° C. or higher and 0° C. or lower.

[0276] A method for using a refrigerating oil according to an eighth aspect is a method for using a refrigerating oil together with a refrigerant composition containing a refrigerant, wherein the refrigerant includes any one of the refrigerants A to E6.

[0277] In this method for using a refrigerating oil, good lubricity can be achieved when a refrigeration cycle is performed using a refrigerant having a sufficiently low GWP or a refrigerant composition containing the refrigerant.

[0278] In the method for using a refrigerating oil in which the refrigerant is the refrigerant A, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) and a coefficient of performance (COP) equal to those of R410A is used.

[0279] In the method for using a refrigerating oil in which the refrigerant is the refrigerant B1 or the refrigerant B2, good lubricity can also be achieved when a refrigerant having a coefficient of performance (COP) and a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) equal to those of R410A and classified with lower flammability (Class 2L) in the standard of The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is used.

[0280] In the method for using a refrigerating oil in which the refrigerant is the refrigerant C1 or the refrigerant C2,

good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) and a coefficient of performance (COP) equal to those of R410A is used.

[0281] In the method for using a refrigerating oil in which the refrigerant is any one of the refrigerants D1 to D5, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) equal to that of R410A and classified with lower flammability (Class 2L) in the standard of The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is used.

[0282] In the method for using a refrigerating oil in which the refrigerant is any one of the refrigerants E1 to E6, good lubricity can also be achieved when a refrigerant having a coefficient of performance (COP) equal to that of R410A is used.

[0283] A method for using a refrigerating oil according to a ninth aspect is the method for using a refrigerating oil according to the eighth aspect, wherein the refrigerating oil has a kinematic viscosity at 40° C. of 1 mm²/s or more and 750 mm²/s or less.

[0284] A method for using a refrigerating oil according to a tenth aspect is the method for using a refrigerating oil according to the eighth aspect or the ninth aspect, wherein the refrigerating oil has a kinematic viscosity at 100° C. of 1 mm²/s or more and 100 mm²/s or less. A method for using a refrigerating oil according to an eleventh aspect is the method for using a refrigerating oil according to any one of the eighth aspect to the tenth aspect, wherein the refrigerating oil has a volume resistivity at 25° C. of 1.0×10^{12} Ω·cm or more.

[0285] A method for using a refrigerating oil according to a twelfth aspect is the method for using a refrigerating oil according to any one of the eighth aspect to the eleventh aspect, wherein the refrigerating oil has an acid number of 0.1 mgKOH/g or less.

[0286] A method for using a refrigerating oil according to a thirteenth aspect is the method for using a refrigerating oil according to any one of the eighth aspect to the twelfth aspect, wherein the refrigerating oil has an ash content of 100 ppm or less.

[0287] The method for using a refrigerating oil according to a fourteenth aspect is the method for using a refrigerating oil according to any one of the eighth aspect to the thirteenth aspect, wherein the refrigerating oil has an aniline point of -100° C. or higher and 0° C. or lower.

[0288] Use of a refrigerating oil according to a fifteenth aspect is use of a refrigerating oil used together with a refrigerant composition containing a refrigerant, wherein the refrigerant includes any one of the refrigerants A to E6.

[0289] In the use of a refrigerating oil, good lubricity can be achieved when a refrigeration cycle is performed using a refrigerant having a sufficiently low GWP or a refrigerant composition containing the refrigerant.

[0290] In the use of a refrigerating oil in which the refrigerant is the refrigerant A, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) and a coefficient of performance (COP) equal to those of R410A is used.

[0291] In the use of a refrigerating oil in which the refrigerant is the refrigerant B1 or the refrigerant B2, good lubricity can also be achieved when a refrigerant having a

coefficient of performance (COP) and a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) equal to those of R410A and classified with lower flammability (Class 2L) in the standard of The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is used.

[0292] In the use of a refrigerating oil in which the refrigerant is the refrigerant C1 or the refrigerant C2, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) and a coefficient of performance (COP) equal to those of R410A is used.

[0293] In the use of a refrigerating oil in which the refrigerant is any one of the refrigerants D1 to D5, good lubricity can also be achieved when a refrigerant having a refrigeration capacity (may also be referred to as a cooling capacity or a capacity) equal to that of R410A and classified with lower flammability (Class 2L) in the standard of The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) is used.

[0294] In the use of a refrigerating oil in which the refrigerant is any one of the refrigerants E1 to E6, good lubricity can also be achieved when a refrigerant having a coefficient of performance (COP) equal to that of R410A is used.

[0295] Use of a refrigerating oil according to a sixteenth aspect is the use of a refrigerating oil according to the fifteenth aspect, wherein the refrigerating oil has a kinematic viscosity at 40° C. of 1 mm²/s or more and 750 mm²/s or less.

[0296] Use of a refrigerating oil according to a seventeenth aspect is the use of a refrigerating oil according to the fifteenth aspect or the sixteenth aspect, wherein the refrigerating oil has a kinematic viscosity at 100° C. of 1 mm²/s or more and 100 mm²/s or less.

[0297] Use of a refrigerating oil according to an eighteenth aspect is the use of a refrigerating oil according to any one of the fifteenth aspect to the seventeenth aspect, wherein the refrigerating oil has a volume resistivity at 25° C. of 1.0×10^{12} Ω·cm or more.

[0298] Use of a refrigerating oil according to a nineteenth aspect is the use of a refrigerating oil according to any one of the fifteenth aspect to the eighteenth aspect, wherein the refrigerating oil has an acid number of 0.1 mgKOH/g or less.

[0299] Use of a refrigerating oil according to a twentieth aspect is the use of a refrigerating oil according to any one of the fifteenth aspect to the nineteenth aspect, wherein the refrigerating oil has an ash content of 100 ppm or less.

[0300] Use of a refrigerating oil according to a twenty-first aspect is the use of a refrigerating oil according to any one of the fifteenth aspect to the twentieth aspect, wherein the refrigerating oil has an aniline point of -100° C. or higher and 0° C. or lower.

BRIEF DESCRIPTION OF THE DRAWINGS

[0301] FIG. 1 is a diagram illustrating an example of a refrigerant circuit included in a refrigeration cycle apparatus.

[0302] FIG. 2 is a schematic view of an instrument used for a flammability test.

[0303] FIG. 3 is a diagram showing points A to T and line segments that connect these points in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass %.

[0304] FIG. 4 is a diagram showing points A to C, D', G, I, J, and K', and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is (100-a) mass %.

[0305] FIG. 5 is a diagram showing points A to C, D', G, I, J, and K', and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 92.9 mass % (the content of R32 is 7.1 mass %).

[0306] FIG. 6 is a diagram showing points A to C, D', G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 88.9 mass % (the content of R32 is 11.1 mass %).

[0307] FIG. 7 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 85.5 mass % (the content of R32 is 14.5 mass %).

[0308] FIG. 8 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 81.8 mass % (the content of R32 is 18.2 mass %).

[0309] FIG. 9 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 78.1 mass % (the content of R32 is 21.9 mass %).

[0310] FIG. 10 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 73.3 mass % (the content of R32 is 26.7 mass %).

[0311] FIG. 11 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 70.7 mass % (the content of R32 is 29.3 mass %).

[0312] FIG. 12 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 63.3 mass % (the content of R32 is 36.7 mass %).

[0313] FIG. 13 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 55.9 mass % (the content of R32 is 44.1 mass %).

[0314] FIG. 14 is a diagram showing points A, B, G, I, J, K', and W, and line segments that connect these points to each other in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 52.2 mass % (the content of R32 is 47.8 mass %).

[0315] FIG. 15 is a view showing points A to C, E, G, and I to W; and line segments that connect points A to C, E, G, and I to W in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass %.

[0316] FIG. 16 is a view showing points A to U; and line segments that connect the points in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass %.

DESCRIPTION OF EMBODIMENTS

(1) Refrigeration Cycle Apparatus

[0317] A refrigeration cycle apparatus contains a refrigerant composition described in Section (4) below and a refrigerating oil.

(2) Refrigerating Oil

[0318] A refrigerating oil can improve the lubricity in the refrigeration cycle apparatus and can also achieve efficient cycle performance by performing a refrigeration cycle such as a refrigeration cycle together with a refrigerant composition.

[0319] Examples of the refrigerating oil include oxygen-containing synthetic oils (e.g., ester-type refrigerating oils and ether-type refrigerating oils) and hydrocarbon refrigerating oils. In particular, ester-type refrigerating oils and ether-type refrigerating oils are preferred from the viewpoint of miscibility with refrigerants or refrigerant compositions. The refrigerating oils may be used alone or in combination of two or more.

[0320] The kinematic viscosity of the refrigerating oil at 40° C. is preferably 1 mm²/s or more and 750 mm²/s or less and more preferably 1 mm²/s or more and 400 mm²/s or less from at least one of the viewpoints of suppressing the deterioration of the lubricity and the hermeticity of compressors, achieving sufficient miscibility with refrigerants under low-temperature conditions, suppressing the lubrication failure of compressors, and improving the heat exchange efficiency of evaporators. Herein, the kinematic viscosity of the refrigerating oil at 100° C. may be, for example, 1 mm²/s or more and 100 mm²/s or less and is more preferably 1 mm²/s or more and 50 mm²/s or less.

[0321] The refrigerating oil preferably has an aniline point of -100° C. or higher and 0° C. or lower. The term "aniline point" herein refers to a numerical value indicating the solubility of, for example, a hydrocarbon solvent, that is, refers to a temperature at which when equal volumes of a sample (herein, refrigerating oil) and aniline are mixed with each other and cooled, turbidity appears because of their immiscibility (provided in JIS K 2256). Note that this value is a value of the refrigerating oil itself in a state in which the refrigerant is not dissolved. By using a refrigerating oil having such an aniline point, for example, even when bearings constituting resin functional components and insulating materials for electric motors are used at positions in contact with the refrigerating oil, the suitability of the refrigerating oil for the resin functional components can be improved. Specifically, if the aniline point is excessively low, the refrigerating oil readily infiltrates the bearings and the insulating materials, and thus the bearings and the like tend to swell. On the other hand, if the aniline point is excessively high, the refrigerating oil does not readily infiltrate the bearings and the insulating materials, and thus the bearings and the like tend to shrink. Accordingly, the deformation of the bearings and the insulating materials due to swelling or shrinking can be prevented by using the refrigerating oil having an aniline point within the above-described predetermined range (-100° C. or higher and 0° C. or lower). If the bearings deform through swelling, the desired length of a gap at a sliding portion cannot be maintained. This may result in an increase in sliding resistance. If the bearings deform through shrinking, the hardness

of the bearings increases, and consequently the bearings may be broken because of vibration of a compressor. In other words, the deformation of the bearings through shrinking may decrease the rigidity of the sliding portion. Furthermore, if the insulating materials (e.g., insulating coating materials and insulating films) of electric motors deform through swelling, the insulating properties of the insulating materials deteriorate. If the insulating materials deform through shrinking, the insulating materials may also be broken as in the case of the bearings, which also deteriorates the insulating properties. In contrast, when the refrigerating oil having an aniline point within the predetermined range is used as described above, the deformation of bearings and insulating materials due to swelling or shrinking can be suppressed, and thus such a problem can be avoided.

[0322] The refrigerating oil is used as a working fluid for a refrigerating machine by being mixed with a refrigerant composition. The content of the refrigerating oil relative to the whole amount of working fluid for a refrigerating machine is preferably 5 mass % or more and 60 mass % or less and more preferably 10 mass % or more and 50 mass % or less.

(2-1) Oxygen-Containing Synthetic Oil

[0323] An ester-type refrigerating oil or an ether-type refrigerating oil serving as an oxygen-containing synthetic oil is mainly constituted by carbon atoms and oxygen atoms. In the ester-type refrigerating oil or the ether-type refrigerating oil, an excessively low ratio (carbon/oxygen molar ratio) of carbon atoms to oxygen atoms increases the hygroscopicity, and an excessively high ratio of carbon atoms to oxygen atoms deteriorates the miscibility with a refrigerant. Therefore, the molar ratio is preferably 2 or more and 7.5 or less.

(2-1-1) Ester-Type Refrigerating Oil

[0324] Examples of base oil components of the ester-type refrigerating oil include dibasic acid ester oils of a dibasic acid and a monohydric alcohol, polyol ester oils of a polyol and a fatty acid, complex ester oils of a polyol, a polybasic acid, and a monohydric alcohol (or a fatty acid), and polyol carbonate oils from the viewpoint of chemical stability.

(Dibasic Acid Ester Oil)

[0325] The dibasic acid ester oil is preferably an ester of a dibasic acid such as oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, phthalic acid, isophthalic acid, or terephthalic acid, in particular, a dibasic acid having 5 to 10 carbon atoms (e.g., glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, or sebacic acid) and a monohydric alcohol having a linear or branched alkyl group and having 1 to 15 carbon atoms (e.g., methanol, ethanol, propanol, butanol, pentanol, hexanol, heptanol, octanol, nonanol, decanol, undecanol, dodecanol, tridecanol, tetradecanol, or pentadecanol). Specific examples of the dibasic acid ester oil include ditridecyl glutarate, di(2-ethylhexyl) adipate, diisodecyl adipate, ditridecyl adipate, and di(3-ethylhexyl) sebacate.

(Polyol Ester Oil)

[0326] The polyol ester oil is an ester synthesized from a polyhydric alcohol and a fatty acid (carboxylic acid), and

has a carbon/oxygen molar ratio of 2 or more and 7.5 or less, preferably 3.2 or more and 5.8 or less.

[0327] The polyhydric alcohol constituting the polyol ester oil is a diol (e.g., ethylene glycol, 1,3-propanediol, propylene glycol, 1,4-butanediol, 1,2-butanediol, 2-methyl-1,3-propanediol, 1,5-pentanediol, neopentyl glycol, 1,6-hexanediol, 2-ethyl-2-methyl-1,3-propanediol, 1,7-heptanediol, 2-methyl-2-propyl-1,3-propanediol, 2,2-diethyl-1,3-propanediol, 1, 8-octanediol, 1,9-nonanediol, 1,10-decanediol, 1,11-undecanediol, or 1,12-dodecanediol) or a polyol having 3 to 20 hydroxyl groups (trimethylolethane, trimethylolpropane, trimethylolbutane, di-(trimethylolpropane), tri-(trimethylolpropane), pentaerythritol, di-(pentaerythritol), tri-(pentaerythritol), glycerol, polyglycerol (glycerol dimer or trimer), 1,3,5-pentanetriol, sorbitol, sorbitan, a sorbitol-glycerol condensate, a polyhydric alcohol such as adonitol, arabitol, xylitol, or mannitol, a saccharide such as xylose, arabinose, ribose, rhamnose, glucose, fructose, galactose, mannose, sorbose, cellobiose, maltose, isomaltose, trehalose, sucrose, raffinose, gentianose, or melezitose, or a partially etherified product of the foregoing). One or two or more polyhydric alcohols may constitute an ester.

[0328] For the fatty acid constituting the polyol ester, the number of carbon atoms is not limited, but is normally 1 to 24. A linear fatty acid or a branched fatty acid is preferred. Examples of the linear fatty acid include acetic acid, propionic acid, butanoic acid, pentanoic acid, hexanoic acid, heptanoic acid, octanoic acid, nonanoic acid, decanoic acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic acid, nonadecanoic acid, eicosanoic acid, oleic acid, linoleic acid, and linolenic acid. The hydrocarbon group that bonds to a carboxy group may have only a saturated hydrocarbon or may have an unsaturated hydrocarbon. Examples of the branched fatty acid include 2-methylpropionic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, 2,2-dimethylpropionic acid, 2-methylpentanoic acid, 3-methylpentanoic acid, 4-methylpentanoic acid, 2,2-dimethylbutanoic acid, 2,3-dimethylbutanoic acid, 3,3-dimethylbutanoic acid, 2-methylhexanoic acid, 3-methylhexanoic acid, 4-methylhexanoic acid, 5-methylhexanoic acid, 2,2-dimethylpentanoic acid, 2,3-dimethylpentanoic acid, 2,4-dimethylpentanoic acid, 3,3-dimethylpentanoic acid, 3,4-dimethylpentanoic acid, 4,4-dimethylpentanoic acid, 2-ethylpentanoic acid, 3-ethylpentanoic acid, 2,2,3-trimethylbutanoic acid, 2,3,3-trimethylbutanoic acid, 2-ethyl-2-methylbutanoic acid, 2-ethyl-3-methylbutanoic acid, 2-methylheptanoic acid, 3-methylheptanoic acid, 4-methylheptanoic acid, 5-methylheptanoic acid, 6-methylheptanoic acid, 2-ethylhexanoic acid, 3-ethylhexanoic acid, 4-ethylhexanoic acid, 2,2-dimethylhexanoic acid, 2,3-dimethylhexanoic acid, 2,4-dimethylhexanoic acid, 2,5-dimethylhexanoic acid, 3,3-dimethylhexanoic acid, 3,4-dimethylhexanoic acid, 3,5-dimethylhexanoic acid, 4,4-dimethylhexanoic acid, 4, 5-dimethylhexanoic acid, 5,5-dimethylhexanoic acid, 2-propylpentanoic acid, 2-methyloctanoic acid, 3-methyloctanoic acid, 4-methyloctanoic acid, 5-methyloctanoic acid, 6-methyloctanoic acid, 7-methyloctanoic acid, 2,2-dimethylheptanoic acid, 2,3-dimethylheptanoic acid, 2,4-dimethylheptanoic acid, 2,5-dimethylheptanoic acid, 2, 6-dimethylheptanoic acid, 3, 3-dimethylheptanoic acid, 3,4-dimethylheptanoic acid, 3, 5-dimethylheptanoic acid, 3, 6-dimethylheptanoic acid, 4,4-

dimethylheptanoic acid, 4, 5-dimethylheptanoic acid, 4, 6-dimethylheptanoic acid, 5,5-dimethylheptanoic acid, 5, 6-dimethylheptanoic acid, 6, 6-dimethylheptanoic acid, 2-methyl-2-ethylhexanoic acid, 2-methyl-3-ethylhexanoic acid, 2-methyl-4-ethylhexanoic acid, 3-methyl-2-ethylhexanoic acid, 3-methyl-3-ethylhexanoic acid, 3-methyl-4-ethylhexanoic acid, 4-methyl-2-ethylhexanoic acid, 4-methyl-3-ethylhexanoic acid, 4-methyl-4-ethylhexanoic acid, 5-methyl-2-ethylhexanoic acid, 5-methyl-3-ethylhexanoic acid, 5-methyl-4-ethylhexanoic acid, 2-ethylheptanoic acid, 3-methyloctanoic acid, 3,5, 5-trimethylhexanoic acid, 2-ethyl-2,3,3-trimethylbutyric acid, 2,2,4,4-tetramethylpentanoic acid, 2,2,3,3-tetramethylpentanoic acid, 2,2,3, 4-tetramethylpentanoic acid, and 2,2-diisopropylpropanoic acid. One or two or more fatty acids selected from the foregoing may constitute an ester.

[0329] One polyhydric alcohol may be used to constitute an ester or a mixture of two or more polyhydric alcohols may be used to constitute an ester. The fatty acid constituting an ester may be a single component, or two or more fatty acids may constitute an ester. The fatty acids may be individual fatty acids of the same type or may be two or more types of fatty acids as a mixture. The polyol ester oil may have a free hydroxyl group.

[0330] Specifically, the polyol ester oil is more preferably an ester of a hindered alcohol such as neopentyl glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, di-(trimethylolpropane), tri-(trimethylolpropane), pentaerythritol, di-(pentaerythritol), or tri-(pentaerythritol); further preferably an ester of neopentyl glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, pentaerythritol, or di-(pentaerythritol); and preferably an ester of neopentyl glycol, trimethylolpropane, pentaerythritol, di-(pentaerythritol), or the like and a fatty acid having 2 to 20 carbon atoms.

[0331] The fatty acid constituting such a polyhydric alcohol fatty acid ester may be only a fatty acid having a linear alkyl group or may be selected from fatty acids having a branched structure. A mixed ester of linear and branched fatty acids may be employed. Furthermore, two or more fatty acids selected from the above fatty acids may be used to constitute an ester.

[0332] Specifically, for example, in the case of a mixed ester of linear and branched fatty acids, the molar ratio of a linear fatty acid having 4 to 6 carbon atoms and a branched fatty acid having 7 to 9 carbon atoms is 15:85 to 90:10, preferably 15:85 to 85:15, more preferably 20:80 to 80:20, further preferably 25:75 to 75:25, and most preferably 30:70 to 70:30. The total content of the linear fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms relative to the whole amount of fatty acid constituting the polyhydric alcohol fatty acid ester is preferably 20 mol % or more. The fatty acid preferably has such a composition that both of sufficient miscibility with a refrigerant and viscosity required as a refrigerating oil are achieved. The content of a fatty acid herein refers to a value relative to the whole amount of fatty acid constituting the polyhydric alcohol fatty acid ester contained in the refrigerating oil.

[0333] In particular, the refrigerating oil preferably contains an ester (hereafter referred to as a "polyhydric alcohol fatty acid ester (A)") in which the molar ratio of the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms is 15:85 to 90:10, the fatty acid

having 4 to 6 carbon atoms contains 2-methylpropionic acid, and the total content of the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms relative to the whole amount of fatty acid constituting the above ester is 20 mol % or more.

[0334] The polyhydric alcohol fatty acid ester (A) includes a complete ester in which all hydroxyl groups of a polyhydric alcohol are esterified, a partial ester in which some hydroxyl groups of a polyhydric alcohol are left without being esterified, and a mixture of a complete ester and a partial ester. The hydroxyl value of the polyhydric alcohol fatty acid ester (A) is preferably 10 mgKOH/g or less, more preferably 5 mgKOH/g or less, and most preferably 3 mgKOH/g or less.

[0335] For the fatty acid constituting the polyhydric alcohol fatty acid ester (A), the molar ratio of the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms is 15:85 to 90:10, preferably 15:85 to 85:15, more preferably 20:80 to 80:20, further preferably 25:75 to 75:25, and most preferably 30:70 to 70:30. The total content of the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms relative to the whole amount of fatty acid constituting the polyhydric alcohol fatty acid ester (A) is 20 mol % or more. In the case where the above conditions for the composition of the fatty acid are not satisfied, if difluoromethane is contained in the refrigerant composition, both of sufficient miscibility with the difluoromethane and viscosity required as a refrigerating oil are not easily achieved at high levels. The content of a fatty acid refers to a value relative to the whole amount of fatty acid constituting the polyhydric alcohol fatty acid ester contained in the refrigerating oil.

[0336] Specific examples of the fatty acid having 4 to 6 carbon atoms include butanoic acid, 2-methylpropionic acid, pentanoic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, 2,2-dimethylpropionic acid, 2-methylpentanoic acid, 3-methylpentanoic acid, 4-methylpentanoic acid, 2,2-dimethylbutanoic acid, 2,3-dimethylbutanoic acid, 3,3-dimethylbutanoic acid, and hexanoic acid. Among them, a fatty acid having a branched structure at an alkyl skeleton, such as 2-methylpropionic acid, is preferred.

[0337] Specific examples of the branched fatty acid having 7 to 9 carbon atoms include 2-methylhexanoic acid, 3-methylhexanoic acid, 4-methylhexanoic acid, 5-methylhexanoic acid, 2,2-dimethylpentanoic acid, 2,3-dimethylpentanoic acid, 2,4-dimethylpentanoic acid, 3,3-dimethylpentanoic acid, 3,4-dimethylpentanoic acid, 4,4-dimethylpentanoic acid, 2-ethylpentanoic acid, 3-ethylpentanoic acid, 1,1,2-trimethylbutanoic acid, 1,2,2-trimethylbutanoic acid, 1-ethyl-1-methylbutanoic acid, 1-ethyl-2-methylbutanoic acid, octanoic acid, 2-ethylhexanoic acid, 3-ethylhexanoic acid, 3,5-dimethylhexanoic acid, 2,4-dimethylhexanoic acid, 3,4-dimethylhexanoic acid, 4,5-dimethylhexanoic acid, 2,2-dimethylhexanoic acid, 2-methylheptanoic acid, 3-methylheptanoic acid, 4-methylheptanoic acid, 5-methylheptanoic acid, 6-methylheptanoic acid, 2-propylpentanoic acid, nonanoic acid, 2,2-dimethylheptanoic acid, 2-methyloctanoic acid, 2-ethylheptanoic acid, 3-methyloctanoic acid, 3,5,5-trimethylhexanoic acid, 2-ethyl-2,3,3-trimethylbutyric acid, 2,2,4,4-tetramethylpentanoic acid, 2,2,3,3-tetramethylpentanoic acid, 2,2,3,4-tetramethylpentanoic acid, and 2,2-diisopropylpropanoic acid.

[0338] The polyhydric alcohol fatty acid ester (A) may contain, as an acid constituent component, a fatty acid other than the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms as long as the molar ratio of the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms is 15:85 to 90:10 and the fatty acid having 4 to 6 carbon atoms contains 2-methylpropionic acid.

[0339] Specific examples of the fatty acid other than the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms include fatty acids having 2 or 3 carbon atoms, such as acetic acid and propionic acid; linear fatty acids having 7 to 9 carbon atoms, such as heptanoic acid, octanoic acid, and nonanoic acid; and fatty acids having 10 to 20 carbon atoms, such as decanoic acid, undecanoic acid, dodecanoic acid, tridecanoic acid, tetradecanoic acid, pentadecanoic acid, hexadecanoic acid, heptadecanoic acid, octadecanoic acid, nonadecanoic acid, eicosanoic acid, and oleic acid.

[0340] When the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms are used in combination with fatty acids other than these fatty acids, the total content of the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms relative to the whole amount of fatty acid constituting the polyhydric alcohol fatty acid ester (A) is preferably 20 mol % or more, more preferably 25 mol % or more, and further preferably 30 mol % or more. When the content is 20 mol % or more, sufficient miscibility with difluoromethane is achieved in the case where the difluoromethane is contained in the refrigerant composition.

[0341] A polyhydric alcohol fatty acid ester (A) containing, as acid constituent components, only 2-methylpropionic acid and 3,5,5-trimethylhexanoic acid is particularly preferred from the viewpoint of achieving both necessary viscosity and miscibility with difluoromethane in the case where the difluoromethane is contained in the refrigerant composition.

[0342] The polyhydric alcohol fatty acid ester may be a mixture of two or more esters having different molecular structures. In this case, individual molecules do not necessarily satisfy the above conditions as long as the whole fatty acid constituting a pentaerythritol fatty acid ester contained in the refrigerating oil satisfies the above conditions.

[0343] As described above, the polyhydric alcohol fatty acid ester (A) contains the fatty acid having 4 to 6 carbon atoms and the branched fatty acid having 7 to 9 carbon atoms as essential acid components constituting the ester and may optionally contain other fatty acids as constituent components. In other words, the polyhydric alcohol fatty acid ester (A) may contain only two fatty acids as acid constituent components or three or more fatty acids having different structures as acid constituent components, but the polyhydric alcohol fatty acid ester preferably contains, as an acid constituent component, only a fatty acid whose carbon atom (α -position carbon atom) adjacent to carbonyl carbon is not quaternary carbon. If the fatty acid constituting the polyhydric alcohol fatty acid ester contains a fatty acid whose α -position carbon atom is quaternary carbon, the lubricity in the presence of difluoromethane in the case where the difluoromethane is contained in the refrigerant composition tends to be insufficient.

[0344] The polyhydric alcohol constituting the polyol ester according to this embodiment is preferably a polyhydric alcohol having 2 to 6 hydroxyl groups.

[0345] Specific examples of the dihydric alcohol (diol) include ethylene glycol, 1,3-propanediol, propylene glycol, 1,4-butanediol, 1,2-butanediol, 2-methyl-1,3-propanediol, 1,5-pentanediol, neopentyl glycol, 1,6-hexanediol, 2-ethyl-2-methyl-1,3-propanediol, 1,7-heptanediol, 2-methyl-2-propyl-1,3-propanediol, 2,2-diethyl-1,3-propanediol, 1, 8-octanediol, 1,9-nonanediol, 1,10-decanediol, 1,11-undecanediol, and 1,12-dodecanediol. Specific examples of the trihydric or higher alcohol include polyhydric alcohols such as trimethylolethane, trimethylolpropane, trimethylolbutane, di-(trimethylolpropane), tri-(trimethylolpropane), pentaerythritol, di-(pentaerythritol), tri-(pentaerythritol), glycerol, polyglycerol (glycerol dimer or trimer), 1,3,5-pentanetriol, sorbitol, sorbitan, sorbitol glycerol condensates, adonitol, arabitol, xylitol, and mannitol; saccharides such as xylose, arabinose, ribose, rhamnose, glucose, fructose, galactose, mannose, sorbose, and cellobiose; and partially etherified products of the foregoing. Among them, in terms of better hydrolysis stability, an ester of a hindered alcohol such as neopentyl glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, di-(trimethylolpropane), tri-(trimethylolpropane), pentaerythritol, di-(pentaerythritol), or tri-(pentaerythritol) is preferably used; an ester of neopentyl glycol, trimethylolethane, trimethylolpropane, trimethylolbutane, pentaerythritol, or di-(pentaerythritol) is more preferably used; and neopentyl glycol, trimethylolpropane, pentaerythritol, or di-(pentaerythritol) is further preferably used. In terms of excellent miscibility with a refrigerant and excellent hydrolysis stability, a mixed ester of pentaerythritol, di-(pentaerythritol), or pentaerythritol and di-(pentaerythritol) is most preferably used.

[0346] Preferred examples of the acid constituent component constituting the polyhydric alcohol fatty acid ester (A) are as follows:

(i) a combination of 1 to 13 acids selected from butanoic acid, 2-methylpropionic acid, pentanoic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, 2,2-dimethylpropionic acid, 2-methylpentanoic acid, 3-methylpentanoic acid, 4-methylpentanoic acid, 2,2-dimethylbutanoic acid, 2,3-dimethylbutanoic acid, 3,3-dimethylbutanoic acid, and hexanoic acid and 1 to 13 acids selected from 2-methylhexanoic acid, 3-methylhexanoic acid, 4-methylhexanoic acid, 5-methylhexanoic acid, 2,2-dimethylpentanoic acid, 2,3-dimethylpentanoic acid, 2,4-dimethylpentanoic acid, 3,3-dimethylpentanoic acid, 3,4-dimethylpentanoic acid, 4,4-dimethylpentanoic acid, 2-ethylpentanoic acid, 3-ethylpentanoic acid, and 2-ethyl-3-methylbutanoic acid;

(ii) a combination of 1 to 13 acids selected from butanoic acid, 2-methylpropionic acid, pentanoic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, 2,2-dimethylpropionic acid, 2-methylpentanoic acid, 3-methylpentanoic acid, 4-methylpentanoic acid, 2,2-dimethylbutanoic acid, 2,3-dimethylbutanoic acid, 3,3-dimethylbutanoic acid, and hexanoic acid and 1 to 25 acids selected from 2-methylheptanoic acid, 3-methylheptanoic acid, 4-methylheptanoic acid, 5-methylheptanoic acid, 6-methylheptanoic acid, 2,2-dimethylhexanoic acid, 3,3-dimethylhexanoic acid, 4,4-dimethylhexanoic acid, 5,5-dimethylhexanoic acid, 2,3-dimethylhexanoic acid, 2,4-dimethylhexanoic acid, 2,5-dimethylhexanoic acid, 3,4-dimethylhexanoic acid, 3,5-dimethylhexanoic acid, 4,5-dimethylhexanoic acid, 2,2,3-

trimethylpentanoic acid, 2,3,3-trimethylpentanoic acid, 2,4,4-trimethylpentanoic acid, 3,4,4-trimethylpentanoic acid, 2-ethylhexanoic acid, 3-ethylhexanoic acid, 2-propylpentanoic acid, 2-methyl-2-ethylpentanoic acid, 2-methyl-3-ethylpentanoic acid, and 3-methyl-3-ethylpentanoic acid; and

(iii) a combination of 1 to 13 acids selected from butanoic acid, 2-methylpropionic acid, pentanoic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, 2,2-dimethylpropionic acid, 2-methylpentanoic acid, 3-methylpentanoic acid, 4-methylpentanoic acid, 2,2-dimethylbutanoic acid, 2,3-dimethylbutanoic acid, 3,3-dimethylbutanoic acid, and hexanoic acid and 1 to 50 acids selected from 2-methyloctanoic acid, 3-methyloctanoic acid, 4-methyloctanoic acid, 5-methyloctanoic acid, 6-methyloctanoic acid, 7-methyloctanoic acid, 8-methylheptanoic acid, 2,2-dimethylheptanoic acid, 3,3-dimethylheptanoic acid, 4,4-dimethylheptanoic acid, 5,5-dimethylheptanoic acid, 6,6-dimethylheptanoic acid, 2,3-dimethylheptanoic acid, 2,4-dimethylheptanoic acid, 2,5-dimethylheptanoic acid, 2,6-dimethylheptanoic acid, 3,4-dimethylheptanoic acid, 3,5-dimethylheptanoic acid, 3,6-dimethylheptanoic acid, 4,5-dimethylheptanoic acid, 4,6-dimethylheptanoic acid, 2-ethylheptanoic acid, 3-ethylheptanoic acid, 4-ethylheptanoic acid, 5-ethylheptanoic acid, 2-propylhexanoic acid, 3-propylhexanoic acid, 2-butylpentanoic acid, 2,2,3-trimethylhexanoic acid, 2,2,3-trimethylhexanoic acid, 2,2,4-trimethylhexanoic acid, 2,2,5-trimethylhexanoic acid, 2,3,4-trimethylhexanoic acid, 2,3,5-trimethylhexanoic acid, 3,3,4-trimethylhexanoic acid, 3,3,5-trimethylhexanoic acid, 3,5,5-trimethylhexanoic acid, 4,4,5-trimethylhexanoic acid, 4,5,5-trimethylhexanoic acid, 2,2,3,3-tetramethylpentanoic acid, 2,2,3,4-tetramethylpentanoic acid, 2,2,4,4-tetramethylpentanoic acid, 2,3,4,4-tetramethylpentanoic acid, 3,3,4,4-tetramethylpentanoic acid, 2,2-diethylpentanoic acid, 2,3-diethylpentanoic acid, 3,3-diethylpentanoic acid, 2-ethyl-2,3,3-trimethylbutyric acid, 3-ethyl-2,2,3-trimethylbutyric acid, and 2,2-diisopropylpropionic acid.

[0347] Further preferred examples of the acid constituent component constituting the polyhydric alcohol fatty acid ester are as follows:

(i) a combination of 2-methylpropionic acid and 1 to 13 acids selected from 2-methylhexanoic acid, 3-methylhexanoic acid, 4-methylhexanoic acid, 5-methylhexanoic acid, 2,2-dimethylpentanoic acid, 2,3-dimethylpentanoic acid, 2,4-dimethylpentanoic acid, 3,3-dimethylpentanoic acid, 3,4-dimethylpentanoic acid, 4,4-dimethylpentanoic acid, 2-ethylpentanoic acid, 3-ethylpentanoic acid, and 2-ethyl-3-methylbutanoic acid;

(ii) a combination of 2-methylpropionic acid and 1 to 25 acids selected from 2-methylheptanoic acid, 3-methylheptanoic acid, 4-methylheptanoic acid, 5-methylheptanoic acid, 6-methylheptanoic acid, 2,2-dimethylhexanoic acid, 3,3-dimethylhexanoic acid, 4,4-dimethylhexanoic acid, 5,5-dimethylhexanoic acid, 2,3-dimethylhexanoic acid, 2,4-dimethylhexanoic acid, 2,5-dimethylhexanoic acid, 3,4-dimethylhexanoic acid, 3,5-dimethylhexanoic acid, 4,5-dimethylhexanoic acid, 2,2,3-trimethylpentanoic acid, 2,3,3-trimethylpentanoic acid, 2,4,4-trimethylpentanoic acid, 3,4,4-trimethylpentanoic acid, 2-ethylhexanoic acid, 3-ethylhexanoic acid, 2-propylpentanoic acid, 2-methyl-2-ethylpentanoic acid, 2-methyl-3-ethylpentanoic acid, and 3-methyl-3-ethylpentanoic acid; and

(iii) a combination of 2-methylpropionic acid and 1 to 50 acids selected from 2-methyloctanoic acid, 3-methyloctanoic acid, 4-methyloctanoic acid, 5-methyloctanoic acid, 6-methyloctanoic acid, 7-methyloctanoic acid, 8-methyloctanoic acid, 2,2-dimethylheptanoic acid, 3,3-dimethylheptanoic acid, 4,4-dimethylheptanoic acid, 5,5-dimethylheptanoic acid, 6,6-dimethylheptanoic acid, 2,3-dimethylheptanoic acid, 2,4-dimethylheptanoic acid, 2,5-dimethylheptanoic acid, 2,6-dimethylheptanoic acid, 3,4-dimethylheptanoic acid, 3,5-dimethylheptanoic acid, 3,6-dimethylheptanoic acid, 4,5-dimethylheptanoic acid, 4,6-dimethylheptanoic acid, 2-ethylheptanoic acid, 3-ethylheptanoic acid, 4-ethylheptanoic acid, 5-ethylheptanoic acid, 2-propylhexanoic acid, 3-propylhexanoic acid, 2-butylpentanoic acid, 2,2,3-trimethylhexanoic acid, 2,2,3-trimethylhexanoic acid, 2,2,4-trimethylhexanoic acid, 2,2,5-trimethylhexanoic acid, 2,3,4-trimethylhexanoic acid, 2,3,5-trimethylhexanoic acid, 3,3,4-trimethylhexanoic acid, 3,3,5-trimethylhexanoic acid, 3,5,5-trimethylhexanoic acid, 4,4,5-trimethylhexanoic acid, 4,5,5-trimethylhexanoic acid, 2,2,3,3-tetramethylpentanoic acid, 2,2,3,4-tetramethylpentanoic acid, 2,2,4,4-tetramethylpentanoic acid, 2,3,4,4-tetramethylpentanoic acid, 3,3,4,4-tetramethylpentanoic acid, 2,2-diethylpentanoic acid, 2,3-diethylpentanoic acid, 3,3-diethylpentanoic acid, 2-ethyl-2,3,3-trimethylbutyric acid, 3-ethyl-2,2,3-trimethylbutyric acid, and 2,2-diisopropylpropionic acid.

tanoic acid, 4-methyloctanoic acid, 5-methyloctanoic acid, 6-methyloctanoic acid, 7-methyloctanoic acid, 8-methyloctanoic acid, 2,2-dimethylheptanoic acid, 3,3-dimethylheptanoic acid, 4,4-dimethylheptanoic acid, 5,5-dimethylheptanoic acid, 6,6-dimethylheptanoic acid, 2,3-dimethylheptanoic acid, 2,4-dimethylheptanoic acid, 2,5-dimethylheptanoic acid, 2,6-dimethylheptanoic acid, 3,4-dimethylheptanoic acid, 3,5-dimethylheptanoic acid, 3,6-dimethylheptanoic acid, 4,5-dimethylheptanoic acid, 4,6-dimethylheptanoic acid, 2-ethylheptanoic acid, 3-ethylheptanoic acid, 4-ethylheptanoic acid, 5-ethylheptanoic acid, 2-propylhexanoic acid, 3-propylhexanoic acid, 2-butylpentanoic acid, 2,2,3-trimethylhexanoic acid, 2,2,3-trimethylhexanoic acid, 2,2,4-trimethylhexanoic acid, 2,2,5-trimethylhexanoic acid, 2,3,4-trimethylhexanoic acid, 2,3,5-trimethylhexanoic acid, 3,3,4-trimethylhexanoic acid, 3,3,5-trimethylhexanoic acid, 3,5,5-trimethylhexanoic acid, 4,4,5-trimethylhexanoic acid, 4,5,5-trimethylhexanoic acid, 2,2,3,3-tetramethylpentanoic acid, 2,2,3,4-tetramethylpentanoic acid, 2,2,4,4-tetramethylpentanoic acid, 2,3,4,4-tetramethylpentanoic acid, 3,3,4,4-tetramethylpentanoic acid, 2,2-diethylpentanoic acid, 2,3-diethylpentanoic acid, 3,3-diethylpentanoic acid, 2-ethyl-2,3,3-trimethylbutyric acid, 3-ethyl-2,2,3-trimethylbutyric acid, and 2,2-diisopropylpropionic acid.

[0348] The content of the polyhydric alcohol fatty acid ester (A) is 50 mass % or more, preferably 60 mass % or more, more preferably 70 mass % or more, and further preferably 75 mass % or more relative to the whole amount of the refrigerating oil. The refrigerating oil according to this embodiment may contain a lubricating base oil other than the polyhydric alcohol fatty acid ester (A) and additives as described later. However, if the content of the polyhydric alcohol fatty acid ester (A) is less than 50 mass %, necessary viscosity and miscibility cannot be achieved at high levels.

[0349] In the refrigerating oil according to this embodiment, the polyhydric alcohol fatty acid ester (A) is mainly used as a base oil. The base oil of the refrigerating oil according to this embodiment may be a polyhydric alcohol fatty acid ester (A) alone (i.e., the content of the polyhydric alcohol fatty acid ester (A) is 100 mass %). However, in addition to the polyhydric alcohol fatty acid ester (A), a base oil other than the polyhydric alcohol fatty acid ester (A) may be further contained to the degree that the excellent performance of the polyhydric alcohol fatty acid ester (A) is not impaired. Examples of the base oil other than the polyhydric alcohol fatty acid ester (A) include hydrocarbon oils such as mineral oils, olefin polymers, alkylidiphenylalkanes, alkyl-naphthalenes, and alkylbenzenes; and esters other than the polyhydric alcohol fatty acid ester (A), such as polyol esters, complex esters, and alicyclic dicarboxylic acid esters, and oxygen-containing synthetic oils (hereafter, may be referred to as "other oxygen-containing synthetic oils") such as polyglycols, polyvinyl ethers, ketones, polyphenyl ethers, silicones, polysiloxanes, and perfluoroethers.

[0350] Among them, the oxygen-containing synthetic oil is preferably an ester other than the polyhydric alcohol fatty acid ester (A), a polyglycol, or a polyvinyl ether and particularly preferably a polyol ester other than the polyhydric alcohol fatty acid ester (A). The polyol ester other than the polyhydric alcohol fatty acid ester (A) is an ester of a fatty acid and a polyhydric alcohol such as neopentyl glycol, trimethylolpropane, trimethylolbutane, pentaerythritol, or dipentaerythritol and is particularly pref-

erably an ester of neopentyl glycol and a fatty acid, an ester of pentaerythritol and a fatty acid, or an ester of dipentaerythritol and a fatty acid.

[0351] The neopentyl glycol ester is preferably an ester of neopentyl glycol and a fatty acid having 5 to 9 carbon atoms. Specific examples of the neopentyl glycol ester include neopentyl glycol di(3,5,5-trimethylhexanoate), neopentyl glycol di(2-ethylhexanoate), neopentyl glycol di(2-methylhexanoate), neopentyl glycol di(2-ethylpentanoate), an ester of neopentyl glycol and 2-methylhexanoic acid, 2-ethylpentanoic acid, an ester of neopentyl glycol and 3-methylhexanoic acid, 5-methylhexanoic acid, an ester of neopentyl glycol and 2-methylhexanoic acid, 2-ethylhexanoic acid, an ester of neopentyl glycol and 3,5-dimethylhexanoic acid, 4,5-dimethylhexanoic acid, 3,4-dimethylhexanoic acid, neopentyl glycol dipentanoate, neopentyl glycol di(2-ethylbutanoate), neopentyl glycol di(2-methylpentanoate), neopentyl glycol di(2-methylbutanoate), and neopentyl glycol di(3-methylbutanoate).

[0352] The pentaerythritol ester is preferably an ester of pentaerythritol and a fatty acid having 5 to 9 carbon atoms. The pentaerythritol ester is, specifically, an ester of pentaerythritol and at least one fatty acid selected from pentanoic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, hexanoic acid, 2-methylpentanoic acid, 2-ethylbutanoic acid, 2-ethylpentanoic acid, 2-methylhexanoic acid, 3,5,5-trimethylhexanoic acid, and 2-ethylhexanoic acid.

[0353] The dipentaerythritol ester is preferably an ester of dipentaerythritol and a fatty acid having 5 to 9 carbon atoms. The dipentaerythritol ester is, specifically, an ester of dipentaerythritol and at least one fatty acid selected from pentanoic acid, 2-methylbutanoic acid, 3-methylbutanoic acid, hexanoic acid, 2-methylpentanoic acid, 2-ethylbutanoic acid, 2-ethylpentanoic acid, 2-methylhexanoic acid, 3,5,5-trimethylhexanoic acid, and 2-ethylhexanoic acid.

[0354] When the refrigerating oil according to this embodiment contains an oxygen-containing synthetic oil other than the polyhydric alcohol fatty acid ester (A), the content of the oxygen-containing synthetic oil other than the polyhydric alcohol fatty acid ester (A) is not limited as long as excellent lubricity and miscibility of the refrigerating oil according to this embodiment are not impaired. When a polyol ester other than the polyhydric alcohol fatty acid ester (A) is contained, the content of the polyol ester is preferably less than 50 mass %, more preferably 45 mass % or less, still more preferably 40 mass % or less, even more preferably 35 mass % or less, further preferably 30 mass % or less, and most preferably 25 mass % or less relative to the whole amount of the refrigerating oil. When an oxygen-containing synthetic oil other than the polyol ester is contained, the content of the oxygen-containing synthetic oil is preferably less than 50 mass %, more preferably 40 mass % or less, and further preferably 30 mass % or less relative to the whole amount of the refrigerating oil. If the content of the polyol ester other than the pentaerythritol fatty acid ester or the oxygen-containing synthetic oil is excessively high, the above-described effects are not sufficiently produced.

[0355] The polyol ester other than the polyhydric alcohol fatty acid ester (A) may be a partial ester in which some hydroxyl groups of a polyhydric alcohol are left without being esterified, a complete ester in which all hydroxyl groups are esterified, or a mixture of a partial ester and a complete ester. The hydroxyl value is preferably 10

mgKOH/g or less, more preferably 5 mgKOH/g or less, and most preferably 3 mgKOH/g or less.

[0356] When the refrigerating oil and the working fluid for a refrigerating machine according to this embodiment contain a polyol ester other than the polyhydric alcohol fatty acid ester (A), the polyol ester may contain one polyol ester having a single structure or a mixture of two or more polyol esters having different structures.

[0357] The polyol ester other than the polyhydric alcohol fatty acid ester (A) may be any of an ester of one fatty acid and one polyhydric alcohol, an ester of two or more fatty acids and one polyhydric alcohol, an ester of one fatty acid and two or more polyhydric alcohols, and an ester of two or more fatty acids and two or more polyhydric alcohols.

[0358] The refrigerating oil according to this embodiment may be constituted by only the polyhydric alcohol fatty acid ester (A) or by the polyhydric alcohol fatty acid ester (A) and other base oils. The refrigerating oil may further contain various additives described later. The working fluid for a refrigerating machine according to this embodiment may also further contain various additives. In the following description, the content of additives is expressed relative to the whole amount of the refrigerating oil, but the content of these components in the working fluid for a refrigerating machine is desirably determined so that the content is within the preferred range described later when expressed relative to the whole amount of the refrigerating oil.

[0359] To further improve the abrasion resistance and load resistance of the refrigerating oil and the working fluid for a refrigerating machine according to this embodiment, at least one phosphorus compound selected from the group consisting of phosphoric acid esters, acidic phosphoric acid esters, thiophosphoric acid esters, amine salts of acidic phosphoric acid esters, chlorinated phosphoric acid esters, and phosphorous acid esters can be added. These phosphorus compounds are esters of phosphoric acid or phosphorous acid and alkanol or polyether-type alcohol, or derivatives thereof.

[0360] Specific examples of the phosphoric acid ester include tributyl phosphate, tripropyl phosphate, trihexyl phosphate, triheptyl phosphate, trioctyl phosphate, trinonyl phosphate, tridecyl phosphate, triundecyl phosphate, tridodecyl phosphate, tritridecyl phosphate, tritetradecyl phosphate, tripentadecyl phosphate, trihexadecyl phosphate, triheptadecyl phosphate, trioctadecyl phosphate, trioleyl phosphate, triphenyl phosphate, tricresyl phosphate, trixylenyl phosphate, cresyldiphenyl phosphate, and xylenyldiphenyl phosphate.

[0361] Examples of the acidic phosphoric acid ester include monobutyl acid phosphate, monopentyl acid phosphate, monohexyl acid phosphate, monoheptyl acid phosphate, mono-octyl acid phosphate, monononyl acid phosphate, monodecyl acid phosphate, monoundecyl acid phosphate, monododecyl acid phosphate, monotridecyl acid phosphate, monotetradecyl acid phosphate, monopentadecyl acid phosphate, monohexadecyl acid phosphate, monoheptadecyl acid phosphate, monooctadecyl acid phosphate, monooleyl acid phosphate, dibutyl acid phosphate, dipentyl acid phosphate, dihexyl acid phosphate, diheptyl acid phosphate, dioctyl acid phosphate, dinonyl acid phosphate, didecyl acid phosphate, diundecyl acid phosphate, didodecyl acid phosphate, ditridecyl acid phosphate, ditetradecyl acid phosphate, dipentadecyl acid phosphate, dihexadecyl acid

phosphate, diheptadecyl acid phosphate, dioctadecyl acid phosphate, and dioleyl acid phosphate.

[0362] Examples of the thiophosphoric acid ester include tributyl phosphorothionate, tripentyl phosphorothionate, trihexyl phosphorothionate, triheptyl phosphorothionate, trioctyl phosphorothionate, trinonyl phosphorothionate, tridecyl phosphorothionate, triundecyl phosphorothionate, tridodecyl phosphorothionate, tritridecyl phosphorothionate, tritetradecyl phosphorothionate, tripentadecyl phosphorothionate, trihexadecyl phosphorothionate, triheptadecyl phosphorothionate, trioctadecyl phosphorothionate, trioleyl phosphorothionate, triphenyl phosphorothionate, tricresyl phosphorothionate, trixylenyl phosphorothionate, cresyldiphenyl phosphorothionate, and xylenyldiphenyl phosphorothionate.

[0363] The amine salt of an acidic phosphoric acid ester is an amine salt of an acidic phosphoric acid ester and a primary, secondary, or tertiary amine that has a linear or branched alkyl group and that has 1 to 24 carbon atoms, preferably 5 to 18 carbon atoms.

[0364] For the amine constituting the amine salt of an acidic phosphoric acid ester, the amine salt is a salt of an amine such as a linear or branched methylamine, ethylamine, propylamine, butylamine, pentylamine, hexylamine, heptylamine, octylamine, nonylamine, decylamine, undecylamine, dodecylamine, tridecylamine, tetradecylamine, pentadecylamine, hexadecylamine, heptadecylamine, octadecylamine, oleylamine, tetracosylamine, dimethylamine, diethylamine, dipropylamine, dibutylamine, dipentylamine, dihexylamine, diheptylamine, dioctylamine, dinonylamine, didecylamine, diundecylamine, didodecylamine, ditridecylamine, ditetradecylamine, dipentadecylamine, dihexadecylamine, diheptadecylamine, dioctadecylamine, dioleylamine, ditetracosylamine, trimethylamine, triethylamine, tripropylamine, tributylamine, tripentylamine, trihexylamine, triheptylamine, trioctylamine, trinonylamine, tridecylamine, triundecylamine, tridodecylamine, tritridecylamine, tritetradecylamine, tripentadecylamine, trihexadecylamine, triheptadecylamine, trioctadecylamine, trioleylamine, or tritetracosylamine. The amine may be a single compound or a mixture of two or more compounds.

[0365] Examples of the chlorinated phosphoric acid ester include tris(dichloropropyl) phosphate, tris(chloroethyl) phosphate, tris(chlorophenyl) phosphate, and polyoxyalkylene.bis[di(chloroalkyl)] phosphate. Examples of the phosphorus acid ester include dibutyl phosphite, dipentyl phosphite, dihexyl phosphite, diheptyl phosphite, dioctyl phosphite, dinonyl phosphite, didecyl phosphite, diundecyl phosphite, didodecyl phosphite, dioleyl phosphite, diphenyl phosphite, dicresyl phosphite, tributyl phosphite, tripentyl phosphite, trihexyl phosphite, triheptyl phosphite, trioctyl phosphite, trinonyl phosphite, tridecyl phosphite, triundecyl phosphite, tridodecyl phosphite, trioleyl phosphite, triphenyl phosphite, and tricresyl phosphite. Mixtures of these compounds can also be used.

[0366] When the refrigerating oil and the working fluid for a refrigerating machine according to this embodiment contain the above-described phosphorus compound, the content of the phosphorus compound is not limited, but is preferably 0.01 to 5.0 mass % and more preferably 0.02 to 3.0 mass % relative to the whole amount of the refrigerating oil (relative to the total amount of the base oil and all the additives). The

above-described phosphorus compounds may be used alone or in combination of two or more.

[0367] The refrigerating oil and the working fluid for a refrigerating machine according to this embodiment may contain a terpene compound to further improve the thermal and chemical stability. The “terpene compound” in the present invention refers to a compound obtained by polymerizing isoprene and a derivative thereof, and a dimer to an octamer of isoprene are preferably used. Specific examples of the terpene compound include monoterpenes such as geraniol, nerol, linalool, citral (including geranial), citronellol, menthol, limonene, terpinol, carvone, ionone, thujone, camphor, and borneol; sesquiterpenes such as farnesene, farnesol, nerolidol, juvenile hormone, humulene, caryophyllene, elemene, cadinol, cadinene, and tutin; diterpenes such as geranylgeraniol, phytol, abietic acid, pimarane, daphnetoxin, taxol, and pimaric acid; sesterterpenes such as geranylarnesene; triterpenes such as squalene, limonin, camelliagenin, hopane, and lanosterol; and tetraterpenes such as carotenoid.

[0368] Among these terpene compounds, the terpene compound is preferably monoterpene, sesquiterpene, or diterpene, more preferably sesquiterpene, and particularly preferably α -farnesene (3,7, 11-trimethyldodeca-1,3,6,10-tetraene) and/or β -farnesene (7,11-dimethyl-3-methylidenedodeca-1,6,10-triene). In the present invention, the terpene compounds may be used alone or in combination of two or more.

[0369] The content of the terpene compound in the refrigerating oil according to this embodiment is not limited, but is preferably 0.001 to 10 mass %, more preferably 0.01 to 5 mass %, and further preferably 0.05 to 3 mass % relative to the whole amount of the refrigerating oil. If the content of the terpene compound is less than 0.001 mass %, an effect of improving the thermal and chemical stability tends to be insufficient. If the content is more than 10 mass %, the lubricity tends to be insufficient. The content of the terpene compound in the working fluid for a refrigerating machine according to this embodiment is desirably determined so that the content is within the above preferred range when expressed relative to the whole amount of the refrigerating oil.

[0370] The refrigerating oil and the working fluid for a refrigerating machine according to this embodiment may contain at least one epoxy compound selected from phenyl glycidyl ether-type epoxy compounds, alkyl glycidyl ether-type epoxy compounds, glycidyl ester-type epoxy compounds, allyloxirane compounds, alkyloxirane compounds, alicyclic epoxy compounds, epoxidized fatty acid monoesters, and epoxidized vegetable oils to further improve the thermal and chemical stability.

[0371] Specific examples of the phenyl glycidyl ether-type epoxy compound include phenyl glycidyl ether and alkylphenyl glycidyl ethers. The alkylphenyl glycidyl ether herein is an alkylphenyl glycidyl ether having 1 to 3 alkyl groups with 1 to 13 carbon atoms. In particular, the alkylphenyl glycidyl ether is preferably an alkylphenyl glycidyl ether having one alkyl group with 4 to 10 carbon atoms, such as n-butylphenyl glycidyl ether, i-butylphenyl glycidyl ether, sec-butylphenyl glycidyl ether, tert-butylphenyl glycidyl ether, pentylphenyl glycidyl ether, hexylphenyl glycidyl ether, heptylphenyl glycidyl ether, octylphenyl glycidyl ether, nonylphenyl glycidyl ether, or decylphenyl glycidyl ether.

[0372] Specific examples of the alkyl glycidyl ether-type epoxy compound include decyl glycidyl ether, undecyl glycidyl ether, dodecyl glycidyl ether, tridecyl glycidyl ether, tetradecyl glycidyl ether, 2-ethylhexyl glycidyl ether, neopentyl glycol diglycidyl ether, trimethylolpropane triglycidyl ether, pentaerythritol tetraglycidyl ether, 1,6-hexanediol diglycidyl ether, sorbitol polyglycidyl ether, polyalkylene glycol monoglycidyl ether, and polyalkylene glycol diglycidyl ether.

[0373] Specific examples of the glycidyl ester-type epoxy compound include phenyl glycidyl ester, alkyl glycidyl esters, and alkenyl glycidyl esters. Preferred examples of the glycidyl ester-type epoxy compound include glycidyl-2,2-dimethyloctanoate, glycidyl benzoate, glycidyl acrylate, and glycidyl methacrylate.

[0374] Specific examples of the allyloxirane compound include 1,2-epoxystyrene and alkyl-1,2-epoxy styrenes.

[0375] Specific examples of the alkyloxirane compound include 1,2-epoxybutane, 1,2-epoxypentane, 1,2-epoxyhexane, 1,2-epoxyheptane, 1,2-epoxyoctane, 1,2-epoxynonane, 1,2-epoxydecane, 1,2-epoxyundecane, 1,2-epoxydodecane, 1,2-epoxytridecane, 1,2-epoxytetradecane, 1,2-epoxypentadecane, 1,2-epoxyhexadecane, 1,2-epoxyheptadecane, 1,1,2-epoxyoctadecane, 2-epoxynonadecane, and 1,2-epoxyeicosane.

[0376] Specific examples of the alicyclic epoxy compound include 1,2-epoxycyclohexane, 1,2-epoxycyclopentane, 3,4-epoxycyclohexylmethyl-3,4-epoxycyclohexane carboxylate, bis(3,4-epoxycyclohexylmethyl) adipate, exo-2,3-epoxynorbomane, bis(3,4-epoxy-6-methylcyclohexylmethyl) adipate, 2-(7-oxabicyclo[4.1.0]hept-3-yl)-spiro(1,3-dioxane-5,3'-[7]oxabicyclo[4.1.0]heptane, 4-(1'-methyleneoxyethyl)-1,2-epoxy-2-methylcyclohexane, and 4-epoxyethyl-1,2-epoxycyclohexane.

[0377] Specific examples of the epoxidized fatty acid monoester include esters of an epoxidized fatty acid having 12 to 20 carbon atoms and an alcohol having 1 to 8 carbon atoms, phenol, or an alkylphenol. In particular, butyl, hexyl, benzyl, cyclohexyl, methoxyethyl, octyl, phenyl, and butyl phenyl esters of epoxystearic acid are preferably used.

[0378] Specific examples of the epoxidized vegetable oil include epoxy compounds of vegetable oils such as soybean oil, linseed oil, and cottonseed oil.

[0379] Among these epoxy compounds, phenyl glycidyl ether-type epoxy compounds, alkyl glycidyl ether-type epoxy compounds, glycidyl ester-type epoxy compounds, and alicyclic epoxy compounds are preferred.

[0380] When the refrigerating oil and the working fluid for a refrigerating machine according to this embodiment contain the above-described epoxy compound, the content of the epoxy compound is not limited, but is preferably 0.01 to 5.0 mass % and more preferably 0.1 to 3.0 mass % relative to the whole amount of the refrigerating oil. The above-described epoxy compounds may be used alone or in combination of two or more.

[0381] The kinematic viscosity of the refrigerating oil containing the polyhydric alcohol fatty acid ester (A) at 40° C. is preferably 20 to 80 mm²/s, more preferably 25 to 75 mm²/s, and most preferably 30 to 70 mm²/s. The kinematic viscosity at 100° C. is preferably 2 to 20 mm²/s and more preferably 3 to 10 mm²/s. When the kinematic viscosity is more than or equal to the lower limit, the viscosity required as a refrigerating oil is easily achieved. On the other hand, when the kinematic viscosity is less than or equal to the

upper limit, sufficient miscibility with difluoromethane in the case where the difluoromethane is contained as a refrigerant composition can be achieved.

[0382] The volume resistivity of the refrigerating oil containing the polyhydric alcohol fatty acid ester (A) is not limited, but is preferably 1.0×10^{12} Ω·cm or more, more preferably 1.0×10^{13} Ω·cm or more, and most preferably 1.0×10^{14} Ω·cm or more. In particular, when the refrigerating oil is used for sealed refrigerating machines, high electric insulation tends to be required. The volume resistivity refers to a value measured at 25° C. in conformity with JIS C 2101 "Testing methods of electrical insulating oils".

[0383] The water content of the refrigerating oil containing the polyhydric alcohol fatty acid ester (A) is not limited, but is preferably 200 ppm or less, more preferably 100 ppm or less, and most preferably 50 ppm or less relative to the whole amount of the refrigerating oil. In particular, when the refrigerating oil is used for sealed refrigerating machines, the water content needs to be low from the viewpoints of the thermal and chemical stability of the refrigerating oil and the influence on electric insulation.

[0384] The acid number of the refrigerating oil containing the polyhydric alcohol fatty acid ester (A) is not limited, but is preferably 0.1 mgKOH/g or less and more preferably 0.05 mgKOH/g or less to prevent corrosion of metals used for refrigerating machines or pipes. In the present invention, the acid number refers to an acid number measured in conformity with JIS K 2501 "Petroleum products and lubricants—Determination of neutralization number".

[0385] The ash content of the refrigerating oil containing the polyhydric alcohol fatty acid ester (A) is not limited, but is preferably 100 ppm or less and more preferably 50 ppm or less to improve the thermal and chemical stability of the refrigerating oil and suppress the generation of sludge and the like. The ash content refers to an ash content measured in conformity with JIS K 2272 "Crude oil and petroleum products—Determination of ash and sulfated ash".

(Complex Ester Oil)

[0386] The complex ester oil is an ester of a fatty acid and a dibasic acid, and a monohydric alcohol and a polyol. The above-described fatty acid, dibasic acid, monohydric alcohol, and polyol can be used.

[0387] Examples of the fatty acid include the fatty acids mentioned in the polyol ester.

[0388] Examples of the dibasic acid include oxalic acid, malonic acid, succinic acid, glutaric acid, adipic acid, pimelic acid, suberic acid, azelaic acid, sebacic acid, phthalic acid, isophthalic acid, and terephthalic acid.

[0389] Examples of the polyol include the polyhydric alcohols in the polyol ester. The complex ester is an ester of such a fatty acid, dibasic acid, and polyol, each of which may be constituted by a single component or a plurality of components.

(Polyol Carbonate Oil)

[0390] The polyol carbonate oil is an ester of a carbonic acid and a polyol.

[0391] Examples of the polyol include the above-described diols and polyols.

[0392] The polyol carbonate oil may be a ring-opened polymer of a cyclic alkylene carbonate.

(2-1-2) Ether-Type Refrigerating Oil

[0393] The ether-type refrigerating oil is, for example, a polyvinyl ether oil or a polyoxyalkylene oil.

(Polyvinyl Ether Oil)

[0394] Examples of the polyvinyl ether oil include polymers of a vinyl ether monomer, copolymers of a vinyl ether monomer and a hydrocarbon monomer having an olefinic double bond, and copolymers of a monomer having an olefinic double bond and a polyoxyalkylene chain and a vinyl ether monomer.

[0395] The carbon/oxygen molar ratio of the polyvinyl ether oil is preferably 2 or more and 7.5 or less and more preferably 2.5 or more and 5.8 or less. If the carbon/oxygen molar ratio is smaller than the above range, the hygroscopicity increases. If the carbon/oxygen molar ratio is larger than the above range, the miscibility deteriorates. The weight-average molecular weight of the polyvinyl ether is preferably 200 or more and 3000 or less and more preferably 500 or more and 1500 or less.

[0396] The pour point of the polyvinyl ether oil is preferably -30°C . or lower. The surface tension of the polyvinyl ether oil at 20°C . is preferably 0.02 N/m or more and 0.04 N/m or less. The density of the polyvinyl ether oil at 15°C . is preferably 0.8 g/cm^3 or more and 1.8 g/cm^3 or less. The saturated water content of the polyvinyl ether oil at a temperature of 30°C . and a relative humidity of 90% is preferably 2000 ppm or more.

[0397] The refrigerating oil may contain polyvinyl ether as a main component. In the case where HFO-1234yf is contained as a refrigerant, the polyvinyl ether serving as a main component of the refrigerating oil has miscibility with HFO-1234yf. When the refrigerating oil has a kinematic viscosity at 40°C . of $400\text{ mm}^2/\text{s}$ or less, HFO-1234yf is dissolved in the refrigerating oil to some extent. When the refrigerating oil has a pour point of -30°C . or lower, the flowability of the refrigerating oil is easily ensured even at positions at which the temperature of the refrigerant composition and the refrigerating oil is low in the refrigerant circuit. When the refrigerating oil has a surface tension at 20°C . of 0.04 N/m or less, the refrigerating oil discharged from a compressor does not readily form large droplets of oil that are not easily carried away by a refrigerant composition. Therefore, the refrigerating oil discharged from the compressor is dissolved in HFO-1234yf and is easily returned to the compressor together with HFO-1234yf.

[0398] When the refrigerating oil has a kinematic viscosity at 40°C . of $30\text{ mm}^2/\text{s}$ or more, an insufficient oil film strength due to excessively low kinematic viscosity is suppressed, and thus good lubricity is easily achieved. When the refrigerating oil has a surface tension at 20°C . of 0.02 N/m or more, the refrigerating oil does not readily form small droplets of oil in a gas refrigerant inside the compressor, which can suppress discharge of a large amount of refrigerating oil from the compressor. Therefore, a sufficient amount of refrigerating oil is easily stored in the compressor.

[0399] When the refrigerating oil has a saturated water content at 30°C ./90% RH of 2000 ppm or more, a relatively high hygroscopicity of the refrigerating oil can be achieved. Thus, when HFO-1234yf is contained as a refrigerant, water in HFO-1234yf can be captured by the refrigerating oil to some extent. HFO-1234yf has a molecular structure that is easily altered or deteriorated because of the influence of

water contained. Therefore, the hygroscopic effects of the refrigerating oil can suppress such deterioration.

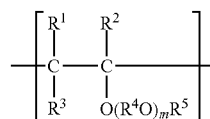
[0400] Furthermore, when a particular resin functional component is disposed in the sealing portion or sliding portion that is in contact with a refrigerant flowing through the refrigerant circuit and the resin functional component is formed of any of polytetrafluoroethylene, polyphenylene sulfide, phenolic resin, polyamide resin, chloroprene rubber, silicon rubber, hydrogenated nitrile rubber, fluororubber, and hydriin rubber, the aniline point of the refrigerating oil is preferably set within a particular range in consideration of the adaptability with the resin functional component. By setting the aniline point in such a manner, for example, the adaptability of bearings constituting the resin functional component with the refrigerating oil is improved. Specifically, if the aniline point is excessively low, the refrigerating oil readily infiltrates bearings or the like, and the bearings or the like readily swell. On the other hand, if the aniline point is excessively high, the refrigerating oil does not readily infiltrate bearings or the like, and the bearings or the like readily shrink. Therefore, by setting the aniline point of the refrigerating oil within a particular range, the swelling or shrinking of the bearings or the like can be prevented. Herein, for example, if each of the bearings or the like deforms through swelling or shrinking, the desired length of a gap at a sliding portion cannot be maintained. This may increase the sliding resistance or decrease the rigidity of the sliding portion. However, when the aniline point of the refrigerating oil is set within a particular range as described above, the deformation of the bearings or the like through swelling or shrinking is suppressed, and thus such a problem can be avoided.

[0401] The vinyl ether monomers may be used alone or in combination of two or more. Examples of the hydrocarbon monomer having an olefinic double bond include ethylene, propylene, various butenes, various pentenes, various hexenes, various heptenes, various octenes, diisobutylene, triisobutylene, styrene, α -methylstyrene, and various alkyl-substituted styrenes. The hydrocarbon monomers having an olefinic double bond may be used alone or in combination of two or more.

[0402] The polyvinyl ether copolymer may be a block copolymer or a random copolymer. The polyvinyl ether oils may be used alone or in combination of two or more.

[0403] A polyvinyl ether oil preferably used has a structural unit represented by general formula (1) below.

[Chem. 1]



(In the formula, R^1 , R^2 , and R^3 may be the same or different and each represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, R^4 represents a divalent hydrocarbon group having 1 to 10 carbon atoms or an ether bond oxygen-containing divalent hydrocarbon group having 2 to 20 carbon atoms, R^5 represents a hydrocarbon group having 1 to 20 carbon atoms, m represents a number at which the average of m in the polyvinyl ether is 0 to 10, R^1 to R^5 may

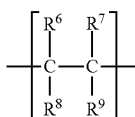
be the same or different in each of structural units, and when m represents 2 or more in one structural unit, a plurality of R⁴O may be the same or different.)

[0404] At least one of R¹, R², and R³ in the general formula (1) preferably represents a hydrogen atom. In particular, all of R¹, R², and R³ preferably represent a hydrogen atom. In the general formula (1), m preferably represents 0 or more and 10 or less, particularly preferably 0 or more and 5 or less, further preferably 0. R⁵ in the general formula (1) represents a hydrocarbon group having 1 to 20 carbon atoms. Specific examples of the hydrocarbon group include alkyl groups such as a methyl group, an ethyl group, a n-propyl group, an isopropyl group, a n-butyl group, an isobutyl group, a sec-butyl group, a tert-butyl group, various pentyl groups, various hexyl groups, various heptyl groups, and various octyl groups; cycloalkyl groups such as a cyclopentyl group, a cyclohexyl group, various methylcyclohexyl groups, various ethylcyclohexyl groups, and various dimethylcyclohexyl groups; aryl groups such as a phenyl group, various methylphenyl groups, various ethylphenyl groups, and various dimethylphenyl groups; and arylalkyl groups such as a benzyl group, various phenylethyl groups, and various methylbenzyl groups. Among the alkyl groups, the cycloalkyl groups, the phenyl group, the aryl groups, and the arylalkyl groups, alkyl groups, in particular, alkyl groups having 1 to 5 carbon atoms are preferred. For the polyvinyl ether oil contained, the ratio of a polyvinyl ether oil with R⁵ representing an alkyl group having 1 or 2 carbon atoms and a polyvinyl ether oil with R⁵ representing an alkyl group having 3 or 4 carbon atoms is preferably 40%:60% to 100%:0%.

[0405] The polyvinyl ether oil according to this embodiment may be a homopolymer constituted by the same structural unit represented by the general formula (1) or a copolymer constituted by two or more structural units. The copolymer may be a block copolymer or a random copolymer.

[0406] The polyvinyl ether oil according to this embodiment may be constituted by only the structural unit represented by the general formula (1) or may be a copolymer further including a structural unit represented by general formula (2) below. In this case, the copolymer may be a block copolymer or a random copolymer.

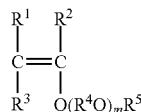
[Chem. 2]



(In the formula, R⁶ to R⁹ may be the same or different and each represent a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms.)

[0407] The vinyl ether monomer is, for example, a compound represented by general formula (3) below.

[Chem. 3]



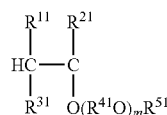
(In the formula, R¹, R², R³, R⁴, R⁵, and m have the same meaning as R¹, R², R³, R⁴, R⁵, and m in the general formula (1), respectively.)

[0408] Examples of various polyvinyl ether compounds corresponding to the above polyvinyl ether compound include vinyl methyl ether; vinyl ethyl ether; vinyl-n-propyl ether; vinyl-isopropyl ether; vinyl-n-butyl ether; vinyl-isobutyl ether; vinyl-sec-butyl ether; vinyl-tert-butyl ether; vinyl-n-pentyl ether; vinyl-n-hexyl ether; vinyl-2-methoxyethyl ether; vinyl-2-ethoxyethyl ether; vinyl-2-methoxy-1-methylethyl ether; vinyl-2-methoxy-propyl ether; vinyl-3,6-dioxahexyl ether; vinyl-3,6,9-trioxadecyl ether; vinyl-1,4-dimethyl-3,6-dioxahexyl ether; vinyl-1,4,7-trimethyl-3,6,9-trioxadecyl ether; vinyl-2,6-dioxa-4-heptyl ether; vinyl-2,6,9-trioxa-4-decyl ether; 1-methoxypropene; 1-ethoxypropene; 1-n-propoxypropene; 1-isopropoxypropene; 1-n-butoxypropene; 1-isobutoxypropene; 1-sec-butoxypropene; 1-tert-butoxypropene; 2-methoxypropene; 2-ethoxypropene; 2-n-propoxypropene; 2-isopropoxypropene; 2-n-butoxypropene; 2-isobutoxypropene; 2-sec-butoxypropene; 2-tert-butoxypropene; 1-methoxy-1-butene; 1-ethoxy-1-butene; 1-n-propoxy-1-butene; 1-isopropoxy-1-butene; 1-n-butoxy-1-butene; isobutoxy-1-butene; 1-sec-butoxy-1-butene; 1-tert-butoxy-1-butene; 2-methoxy-1-butene; 2-ethoxy-1-butene; 2-n-propoxy-1-butene; 2-isopropoxy-1-butene; 2-n-butoxy-1-butene; 2-isobutoxy-1-butene; 2-sec-butoxy-1-butene; 2-tert-butoxy-1-butene; 2-methoxy-2-butene; 2-ethoxy-2-butene; 2-n-propoxy-2-butene; 2-isopropoxy-2-butene; 2-n-butoxy-2-butene; 2-isobutoxy-2-butene; 2-sec-butoxy-2-butene; and 2-tert-butoxy-2-butene. These vinyl ether monomers can be produced by a publicly known method.

[0409] The end of the polyvinyl ether compound having the structural unit represented by the general formula (1) can be converted into a desired structure by a method described in the present disclosure and a publicly known method. Examples of the group introduced by conversion include saturated hydrocarbons, ethers, alcohols, ketones, amides, and nitriles.

[0410] The polyvinyl ether compound preferably has the following end structures.

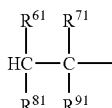
[Chem. 4]



(In the formula, R¹¹, R²¹, and R³¹ may be the same or different and each represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, R⁴¹ represents a divalent hydrocarbon group having 1 to 10 carbon atoms or

an ether bond oxygen-containing divalent hydrocarbon group having 2 to 20 carbon atoms, R⁵¹ represents a hydrocarbon group having 1 to 20 carbon atoms, m represents a number at which the average of m in the polyvinyl ether is 0 to 10, and when m represents 2 or more, a plurality of R⁴¹O may be the same or different.)

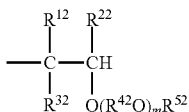
[Chem. 5]



(5)

(In the formula, R⁶¹, R⁷¹, R⁸¹, and R⁹¹ may be the same or different and each represent a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms.)

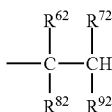
[Chem. 6]



(6)

(In the formula, R¹², R²², and R³² may be the same or different and each represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms, R⁴² represents a divalent hydrocarbon group having 1 to 10 carbon atoms or an ether bond oxygen-containing divalent hydrocarbon group having 2 to 20 carbon atoms, R⁵² represents a hydrocarbon group having 1 to 20 carbon atoms, m represents a number at which the average of m in the polyvinyl ether is 0 to 10, and when m represents 2 or more, a plurality of R⁴²O may be the same or different.)

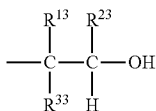
[Chem. 7]



(7)

(In the formula, R⁶², R⁷², R⁸², and R⁹² may be the same or different and each represent a hydrogen atom or a hydrocarbon group having 1 to 20 carbon atoms.)

[Chem. 8]



(8)

(In the formula, R¹³, R²³, and R³³ may be the same or different and each represent a hydrogen atom or a hydrocarbon group having 1 to 8 carbon atoms.)

[0411] The polyvinyl ether oil according to this embodiment can be produced by polymerizing the above-described monomer through, for example, radical polymerization, cationic polymerization, or radiation-induced polymerization. After completion of the polymerization reaction, a typical separation/purification method is performed when necessary to obtain a desired polyvinyl ether compound having a structural unit represented by the general formula (1).

(Polyoxyalkylene Oil)

[0412] The polyoxyalkylene oil is a polyoxyalkylene compound obtained by, for example, polymerizing an alkylene oxide having 2 to 4 carbon atoms (e.g., ethylene oxide or propylene oxide) using water or a hydroxyl group-containing compound as an initiator. The hydroxyl group of the polyoxyalkylene compound may be etherified or esterified. The polyoxyalkylene oil may contain an oxyalkylene unit of the same type or two or more oxyalkylene units in one molecule. The polyoxyalkylene oil preferably contains at least an oxypropylene unit in one molecule.

[0413] Specifically, the polyoxyalkylene oil is, for example, a compound represented by general formula (9) below.



(In the formula, R¹⁰¹ represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, an acyl group having 2 to 10 carbon atoms, or an aliphatic hydrocarbon group having 2 to 6 bonding sites and 1 to 10 carbon atoms, R¹⁰² represents an alkylene group having 2 to 4 carbon atoms, R¹⁰³ represents a hydrogen atom, an alkyl group having 1 to 10 carbon atoms, or an acyl group having 2 to 10 carbon atoms, l represents an integer of 1 to 6, and k represents a number at which the average of kx1 is 6 to 80.)

[0414] In the general formula (9), the alkyl group represented by R¹⁰¹ and R¹⁰³ may be a linear, branched, or cyclic alkyl group. Specific examples of the alkyl group include a methyl group, an ethyl group, a n-propyl group, an isopropyl group, various butyl groups, various pentyl groups, various hexyl groups, various heptyl groups, various octyl groups, various nonyl groups, various decyl groups, a cyclopentyl group, and a cyclohexyl group. If the number of carbon atoms of the alkyl group exceeds 10, the miscibility with a refrigerant deteriorates, which may cause phase separation. The number of carbon atoms of the alkyl group is preferably 1 to 6.

[0415] The acyl group represented by R¹⁰¹ and R¹⁰³ may have a linear, branched, or cyclic alkyl group moiety. Specific examples of the alkyl group moiety of the acyl group include various groups having 1 to 9 carbon atoms that are mentioned as specific examples of the alkyl group. If the number of carbon atoms of the acyl group exceeds 10, the miscibility with a refrigerant deteriorates, which may cause phase separation. The number of carbon atoms of the acyl group is preferably 2 to 6.

[0416] When R¹⁰¹ and R¹⁰³ each represent an alkyl group or an acyl group, R¹⁰¹ and R¹⁰³ may be the same or different.

[0417] Furthermore, when l represents 2 or more, a plurality of R¹⁰³ in one molecule may be the same or different.

[0418] When R¹⁰¹ represents an aliphatic hydrocarbon group having 2 to 6 bonding sites and 1 to 10 carbon atoms, the aliphatic hydrocarbon group may be a linear group or a cyclic group. Examples of the aliphatic hydrocarbon group

having two bonding sites include an ethylene group, a propylene group, a butylene group, a pentylene group, a hexylene group, a heptylene group, an octylene group, a nonylene group, a decylene group, a cyclopentylene group, and a cyclohexylene group. Examples of the aliphatic hydrocarbon group having 3 to 6 bonding sites include residual groups obtained by removing hydroxyl groups from polyhydric alcohols such as trimethylolpropane, glycerol, pentaerythritol, sorbitol, 1,2,3-trihydroxycyclohexane, and 1,3,5-trihydroxycyclohexane.

[0419] If the number of carbon atoms of the aliphatic hydrocarbon group exceeds 10, the miscibility with a refrigerant deteriorates, which may cause phase separation. The number of carbon atoms is preferably 2 to 6.

[0420] R^{102} in the general formula (9) represents an alkylene group having 2 to 4 carbon atoms. Examples of the oxyalkylene group serving as a repeating unit include an oxyethylene group, an oxypropylene group, and an oxybutylene group. The polyoxyalkylene oil may contain an oxyalkylene group of the same type or two or more oxyalkylene groups in one molecule, but preferably contains at least an oxypropylene unit in one molecule. In particular, the content of the oxypropylene unit in the oxyalkylene unit is suitably 50 mol % or more.

[0421] In the general formula (9), 1 represents an integer of 1 to 6, which can be determined in accordance with the number of bonding sites of R^{101} . For example, when R^{101} represents an alkyl group or an acyl group, 1 represents 1. When R^{101} represents an aliphatic hydrocarbon group having 2, 3, 4, 5, and 6 bonding sites, 1 represents 2, 3, 4, 5, and 6, respectively. Preferably, 1 represents 1 or 2. Furthermore, k preferably represents a number at which the average of $k \times 1$ is 6 to 80.

[0422] For the structure of the polyoxyalkylene oil, a polyoxypropylene diol dimethyl ether represented by general formula (10) below and a poly(oxyethylene/oxypropylene) diol dimethyl ether represented by general formula (11) below are suitable from the viewpoints of economy and the above-described effects. Furthermore, a polyoxypropylene diol monobutyl ether represented by general formula (12) below, a polyoxypropylene diol monomethyl ether represented by general formula (13) below, a poly(oxyethylene/oxypropylene) diol monomethyl ether represented by general formula (14) below, a poly(oxyethylene/oxypropylene) diol monobutyl ether represented by general formula (15) below, and a polyoxypropylene diol diacetate represented by general formula (16) below are suitable from the viewpoint of economy and the like.



(In the formula, h represents 6 to 80.)



(In the formula, i and j each represent 1 or more and the sum of i and j is 6 to 80.)



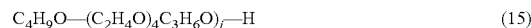
(In the formula, h represents 6 to 80.)



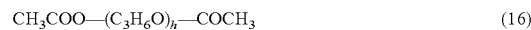
(In the formula, h represents 6 to 80.)



(In the formula, i and j each represent 1 or more and the sum of i and j is 6 to 80.)



(In the formula, i and j each represent 1 or more and the sum of i and j is 6 to 80.)



(In the formula, h represents 6 to 80.)

[0423] The polyoxyalkylene oils may be used alone or in combination of two or more.

(2-2) Hydrocarbon Refrigerating Oil

[0424] The hydrocarbon refrigerating oil that can be used is, for example, an alkylbenzene.

[0425] The alkylbenzene that can be used is a branched alkylbenzene synthesized from propylene polymer and benzene serving as raw materials using a catalyst such as hydrogen fluoride or a linear alkylbenzene synthesized from normal paraffin and benzene serving as raw materials using the same catalyst. The number of carbon atoms of the alkyl group is preferably 1 to 30 and more preferably 4 to 20 from the viewpoint of achieving a viscosity appropriate as a lubricating base oil. The number of alkyl groups in one molecule of the alkylbenzene is dependent on the number of carbon atoms of the alkyl group, but is preferably 1 to 4 and more preferably 1 to 3 to control the viscosity within the predetermined range.

[0426] The hydrocarbon refrigerating oil preferably circulates through a refrigeration cycle system together with a refrigerant. Although it is most preferable that the refrigerating oil is soluble with a refrigerant, for example, a refrigerating oil (e.g., a refrigerating oil disclosed in Japanese Patent No. 2803451) having low solubility can also be used as long as the refrigerating oil is capable of circulating through a refrigeration cycle system together with a refrigerant. To allow the refrigerating oil to circulate through a refrigeration cycle system, the refrigerating oil is required to have a low kinematic viscosity. The kinematic viscosity of the hydrocarbon refrigerating oil at 40° C. is preferably 1 mm²/s or more and 50 mm²/s or less and more preferably 1 mm²/s or more and 25 mm²/s or less.

[0427] These refrigerating oils may be used alone or in combination of two or more.

[0428] The content of the hydrocarbon refrigerating oil in the working fluid for a refrigerating machine may be, for example, 10 parts by mass or more and 100 parts by mass or less and is more preferably 20 parts by mass or more and 50 parts by mass or less relative to 100 parts by mass of the refrigerant composition.

(2-3) Additive

[0429] The refrigerating oil may contain one or two or more additives.

[0430] Examples of the additives include an acid scavenger, an extreme pressure agent, an antioxidant, an antifoaming agent, an oiliness improver, a metal deactivator such as a copper deactivator, an anti-wear agent, and a compatibilizer.

[0431] Examples of the acid scavenger that can be used include epoxy compounds such as phenyl glycidyl ether, alkyl glycidyl ether, alkylene glycol glycidyl ether, cyclohexene oxide, α -olefin oxide, and epoxidized soybean oil; and carbodiimides. Among them, phenyl glycidyl ether, alkyl glycidyl ether, alkylene glycol glycidyl ether, cyclohexene oxide, and α -olefin oxide are preferred from the

viewpoint of miscibility. The alkyl group of the alkyl glycidyl ether and the alkylene group of the alkylene glycol glycidyl ether may have a branched structure. The number of carbon atoms may be 3 or more and 30 or less, and is more preferably 4 or more and 24 or less and further preferably 6 or more and 16 or less. The total number of carbon atoms of the α -olefin oxide may be 4 or more and 50 or less, and is more preferably 4 or more and 24 or less and further preferably 6 or more and 16 or less. The acid scavengers may be used alone or in combination of two or more.

[0432] The extreme pressure agent may contain, for example, a phosphoric acid ester. Examples of the phosphoric acid ester that can be used include phosphoric acid esters, phosphorous acid esters, acidic phosphoric acid esters, and acidic phosphorous acid esters. The extreme pressure agent may contain an amine salt of a phosphoric acid ester, a phosphorous acid ester, an acidic phosphoric acid ester, or an acidic phosphorous acid ester.

[0433] Examples of the phosphoric acid ester include triaryl phosphates, trialkyl phosphates, trialkylaryl phosphates, triarylalkyl phosphates, and trialkenyl phosphates. Specific examples of the phosphoric acid ester include triphenyl phosphate, tricresyl phosphate, benzyl diphenyl phosphate, ethyl diphenyl phosphate, tributyl phosphate, ethyl dibutyl phosphate, cresyl diphenyl phosphate, dicresyl phenyl phosphate, ethylphenyl diphenyl phosphate, diethylphenyl phenyl phosphate, propylphenyl diphenyl phosphate, dipropylphenyl phenyl phosphate, triethylphenyl phosphate, tripropylphenyl phosphate, butylphenyl diphenyl phosphate, dibutylphenyl phenyl phosphate, tributylphenyl phosphate, trihexyl phosphate, tri(2-ethylhexyl) phosphate, tridecyl phosphate, trilauryl phosphate, trimyristyl phosphate, tripalmityl phosphate, tristearyl phosphate, and trioleyl phosphate.

[0434] Specific examples of the phosphorous acid ester include triethyl phosphite, tributyl phosphite, triphenyl phosphite, tricresyl phosphite, tri(nonylphenyl) phosphite, tri(2-ethylhexyl) phosphite, tridecyl phosphite, trilauryl phosphite, triisooctyl phosphite, diphenylisodecyl phosphite, tristearyl phosphite, and trioleyl phosphite.

[0435] Specific examples of the acidic phosphoric acid ester include 2-ethylhexyl acid phosphate, ethyl acid phosphate, butyl acid phosphate, oleyl acid phosphate, tetracosyl acid phosphate, isodecyl acid phosphate, lauryl acid phosphate, tridecyl acid phosphate, stearyl acid phosphate, and isostearyl acid phosphate.

[0436] Specific examples of the acidic phosphorous acid ester include dibutyl hydrogen phosphite, dilauryl hydrogen phosphite, dioleyl hydrogen phosphite, distearyl hydrogen phosphite, and diphenyl hydrogen phosphite. Among the phosphoric acid esters, oleyl acid phosphate and stearyl acid phosphate are suitably used.

[0437] Among amines used for amine salts of phosphoric acid esters, phosphorous acid esters, acidic phosphoric acid esters, or acidic phosphorous acid esters, specific examples of mono-substituted amines include butylamine, pentylamine, hexylamine, cyclohexylamine, octylamine, laurylamine, stearylamine, oleylamine, and benzylamine. Specific examples of di-substituted amines include dibutylamine, dipentylamine, dihexylamine, dicyclohexylamine, dioctylamine, dilaurylamine, distearylamine, dioleylamine, dibenzylamine, stearyl.monoethanolamine, decyl.monoethanolamine, hexyl.monoethanolamine, benzyl.monoethanolamine, phenyl.monoethanolamine, and tolyl.

monoethanolamine. Specific examples of tri-substituted amines include tributylamine, tripentylamine, trihexylamine, tricyclohexylamine, trioctylamine, trilaurylamine, tristearylamine, trioleylamine, tribenzylamine, dioleyl.monoethanolamine, dilauryl.monoethanolamine, dioctyl.monoethanolamine, dihexyl.monoethanolamine, dibutyl.monoethanolamine, oleyl.diethanolamine, stearyl.dipropanolamine, lauryl.diethanolamine, octyl.dipropanolamine, butyl.diethanolamine, benzyl.diethanolamine, phenyl.diethanolamine, tolyl.dipropanolamine, xylyl.diethanolamine, triethanolamine, and tripropanolamine.

[0438] Examples of extreme pressure agents other than the above-described extreme pressure agents include extreme pressure agents based on organosulfur compounds such as monosulfides, polysulfides, sulfoxides, sulfones, thiosulfonates, sulfurized fats and oils, thiocarbonates, thiophenes, thiazoles, and methanesulfonates; extreme pressure agents based on thiophosphoric acid esters such as thiophosphoric acid triesters; extreme pressure agents based on esters such as higher fatty acids, hydroxyaryl fatty acids, polyhydric alcohol esters, and acrylic acid esters; extreme pressure agents based on organochlorine compounds such as chlorinated hydrocarbons, e.g., chlorinated paraffin and chlorinated carboxylic acid derivatives; extreme pressure agents based on fluoroorganic compounds such as fluorinated aliphatic carboxylic acids, fluorinated ethylene resins, fluorinated alkylpolysiloxanes, and fluorinated graphites; extreme pressure agents based on alcohols such as higher alcohols; and extreme pressure agents based on metal compounds such as naphthenic acid salts (e.g., lead naphthenate), fatty acid salts (e.g., lead fatty acid), thiophosphoric acid salts (e.g., zinc dialkyldithiophosphate), thiocarbamic acid salts, organomolybdenum compounds, organotin compounds, organogermanium compounds, and boric acid esters.

[0439] The antioxidant that can be used is, for example, a phenol-based antioxidant or an amine-based antioxidant. Examples of the phenol-based antioxidant include 2,6-di-tert-butyl-4-methylphenol (DBPC), 2,6-di-tert-butyl-4-ethylphenol, 2,2'-methylenebis(4-methyl-6-tert-butylphenol), 2,4-dimethyl-6-tert-butylphenol, 2,6-di-tert-butylphenol, di-tert-butyl-p-cresol, and bisphenol A. Examples of the amine-based antioxidant include N,N'-diisopropyl-p-phenylenediamine, N,N'-di-sec-butyl-p-phenylenediamine, phenyl- α -naphthylamine, N,N'-di-phenyl-p-phenylenediamine, and N,N-di(2-naphthyl)-p-phenylenediamine. An oxygen scavenger that captures oxygen can also be used as the antioxidant.

[0440] The antifoaming agent that can be used is, for example, a silicon compound.

[0441] The oiliness improver that can be used is, for example, a higher alcohol or a fatty acid.

[0442] The metal deactivator such as a copper deactivator that can be used is, for example, benzotriazole or a derivative thereof.

[0443] The anti-wear agent that can be used is, for example, zinc dithiophosphate.

[0444] The compatibilizer is not limited, and can be appropriately selected from commonly used compatibilizers. The compatibilizers may be used alone or in combination of two or more. Examples of the compatibilizer include polyoxyalkylene glycol ethers, amides, nitriles, ketones, chlorocarbons, esters, lactones, aryl ethers, fluoroethers, and

1,1,1-trifluoroalkanes. The compatibilizer is particularly preferably a polyoxyalkylene glycol ether.

[0445] The refrigerating oil may optionally contain, for example, a load-bearing additive, a chlorine scavenger, a detergent dispersant, a viscosity index improver, a heat resistance improver, a stabilizer, a corrosion inhibitor, a pour-point depressant, and an anticorrosive.

[0446] The content of each additive in the refrigerating oil may be 0.01 mass % or more and 5 mass % or less and is preferably 0.05 mass % or more and 3 mass % or less. The content of the additive in the working fluid for a refrigerating machine constituted by the refrigerant composition and the refrigerating oil is preferably 5 mass % or less and more preferably 3 mass % or less.

[0447] The refrigerating oil preferably has a chlorine concentration of 50 ppm or less and preferably has a sulfur concentration of 50 ppm or less.

(3) Refrigerant Circuit

[0448] FIG. 1 illustrates an example of a refrigerant circuit 10 included in an air conditioner 1 that is a refrigeration cycle apparatus.

[0449] The air conditioner 1 is an apparatus used for indoor cooling and/or heating through a vapor-compression refrigeration cycle operation. The air conditioner 1 mainly includes an outdoor unit 2, an indoor unit 3, and a liquid-side connection pipe 9 and a gas-side connection pipe 8 that each connect the outdoor unit 2 and the indoor unit 3.

[0450] The refrigerant circuit 10 included in the air conditioner 1 includes a compressor 4, an outdoor heat exchanger 5, an expansion valve 6, and an indoor heat exchanger 7, which are connected to one another through the liquid-side connection pipe 9, the gas-side connection pipe 8, and other refrigerant pipes to constitute a compression refrigerant circuit. The air conditioner 1 includes a micro-computer, a memory, and the like and also includes a control unit configured to drive and control various actuators.

[0451] A working fluid for a refrigerating machine containing the refrigerant composition serving as a refrigerant and the refrigerating oil is enclosed in the refrigerant circuit 10.

(3-1) Indoor Unit

[0452] The indoor unit 3 is disposed on an indoor ceiling surface or wall surface. The indoor unit 3 is connected to the outdoor unit 2 through the liquid-side connection pipe 9 and the gas-side connection pipe 8 and constitutes a part of the refrigerant circuit 10. The refrigerant circuit 10 may include a plurality of indoor units 3 connected in parallel.

[0453] The indoor unit 3 includes the indoor heat exchanger 7 and an indoor fan 13.

[0454] The indoor heat exchanger 7 is not limited, and is constituted by, for example, a heat transfer tube and many fins. The indoor heat exchanger 7 functions as a refrigerant evaporator during cooling operation to cool indoor air and functions as a refrigerant condenser during heating operation to heat indoor air.

[0455] The indoor fan 13 sucks indoor air into the indoor unit 3 to cause heat exchange with the refrigerant in the indoor heat exchanger 7 and then generates air flow supplied to the interior as supply air. The indoor fan 13 includes an indoor fan motor.

(3-2) Outdoor Unit

[0456] The outdoor unit 2 is disposed outdoors and connected to the indoor unit 3 through the liquid-side connection pipe 9 and the gas-side connection pipe 8.

[0457] The outdoor unit 2 includes, for example, the compressor 4, the outdoor heat exchanger 5, an outdoor fan 12, the expansion valve 6, an accumulator 11, a four-way switching valve 10, a liquid-side shutoff valve 14, and a gas-side shutoff valve 15.

[0458] The compressor 4 is, for example, a positive-displacement compressor driven by a compressor motor. The compressor motor may be driven by, for example, receiving power supply through an inverter device (not illustrated).

[0459] The outdoor heat exchanger 5 is not limited, and is constituted by, for example, a heat transfer tube and many fins. The outdoor heat exchanger 5 functions as a refrigerant condenser during cooling operation and functions as a refrigerant evaporator during heating operation.

[0460] The outdoor fan 12 sucks outdoor air into the outdoor unit 2 to cause heat exchange with the refrigerant in the outdoor heat exchanger 5 and then generates air flow discharged outdoors. The outdoor fan 12 includes an outdoor fan motor.

[0461] The expansion valve 6 can control the pressure of a refrigerant passing therethrough by adjusting the valve opening degree.

[0462] The accumulator 11 is disposed on the suction side of the compressor 4 between the four-way switching valve 10 and the compressor 4 and separates a liquid refrigerant and a gaseous refrigerant from each other.

[0463] The four-way switching valve 10 can switch the connection state between a cooling operation connection state in which the discharge side of the compressor 4 and the outdoor heat exchanger 5 are connected while the downstream side of the accumulator 11 and the gas-side shutoff valve 15 are connected and a heating operation connection state in which the discharge side of the compressor 4 and the gas-side shutoff valve 15 are connected while the downstream side of the accumulator 11 and the outdoor heat exchanger 5 are connected.

[0464] The liquid-side shutoff valve 14 and the gas-side shutoff valve 15 are valves disposed at connecting ports with outside apparatuses and pipes (specifically, the liquid-side connection pipe 9 and the gas-side connection pipe 8).

(3-3) Refrigeration Cycle

[0465] In the air conditioner 1, the four-way switching valve 10 is in a cooling operation connection state during cooling operation. A high-temperature and high-pressure refrigerant discharged from the compressor 4 is condensed at the outdoor heat exchanger 5 that functions as a refrigerant condenser, decompressed when passing through the expansion valve 6, and supplied to the gas side of the indoor unit 3 through the liquid-side connection pipe 9. The refrigerant that has been supplied to the indoor unit 3 is evaporated at the indoor heat exchanger 7 that functions as a refrigerant evaporator and sucked into the compressor 4 through the gas-side connection pipe 8 and the accumulator 11 of the outdoor unit 2.

[0466] In the air conditioner 1, the four-way switching valve 10 is in a heating operation connection state during heating operation. A high-temperature and high-pressure

refrigerant discharged from the compressor 4 is sent to the gas side of the indoor unit 3 through the gas-side connection pipe 8. The refrigerant that has been sent to the indoor unit 3 is condensed at the indoor heat exchanger 7 that functions as a refrigerant condenser and sent to the expansion valve 6 of the outdoor unit 2 through the liquid-side connection pipe 9. The refrigerant decompressed when passing through the expansion valve 6 is evaporated at the outdoor heat exchanger 5 that functions as a refrigerant evaporator and sucked into the compressor 4 through the accumulator 11.

[0467] The refrigeration cycle apparatus is not limited. Examples of the refrigeration cycle apparatus include cooling apparatuses of room air conditioners, package air conditioners, refrigerators, car air conditioners, water heaters, dehumidifiers, freezers, cold stores, vending machines, showcases, chemical plants, and the like. In particular, the refrigeration cycle apparatus is preferably used in a refrigerating machine including a hermetic compressor. Each of the refrigerating oils according to this embodiment can be used for any of, for example, reciprocating compressors, rotary compressors, and centrifugal compressors. In these refrigerating machines, the refrigerating oil according to this embodiment is used as a working fluid for a refrigerating machine obtained by being mixed with the refrigerant composition.

(4) Refrigerant and Refrigerant Composition

(4-1) Definition of Terms

[0468] In the present specification, the term “refrigerant” includes at least compounds that are specified in ISO 817 (International Organization for Standardization), and that are given a refrigerant number (ASHRAE number) representing the type of refrigerant with “R” at the beginning; and further includes refrigerants that have properties equivalent to those of such refrigerants, even though a refrigerant number is not yet given. Refrigerants are broadly divided into fluorocarbon compounds and non-fluorocarbon compounds in terms of the structure of the compounds. Fluorocarbon compounds include chlorofluorocarbons (CFC), hydrochlorofluorocarbons (HCFC), and hydrofluorocarbons (HFC). Non-fluorocarbon compounds include propane (R290), propylene (R1270), butane (R600), isobutane (R600a), carbon dioxide (R744), ammonia (R717), and the like. Note that the term “refrigerant” includes a mixture of a plurality of refrigerants.

[0469] In the present specification, the phase “refrigerant composition” includes a refrigerant itself (including a mixture of refrigerants) and other components, and is distinguished from a refrigerant itself (including a mixture of refrigerants). The “refrigerant composition” includes a composition that can be used to obtain the working fluid for a refrigerating machine by mixing at least with a refrigerating oil.

[0470] In the present specification, the phase “working fluid for a refrigerating machine” includes a composition including a refrigerant and a refrigerating oil, and is distinguished from the “refrigerant composition”. The phase “working fluid for a refrigerating machine” may be referred to as a “refrigeration oil-containing working fluid”.

[0471] It should be noted that the phase “composition comprising a refrigerant” can be used as a phase including at least those three embodiments of “refrigerant”, “refriger-

ant composition”, and “working fluid for a refrigerating machine (refrigeration oil-containing working fluid)”.

[0472] In the present specification, when the term “alternative” is used in a context in which the first refrigerant is replaced with the second refrigerant, the first type of “alternative” means that equipment designed for operation using the first refrigerant can be operated using the second refrigerant under optimum conditions, optionally with changes of only a few parts (at least one of the following: refrigeration oil, gasket, packing, expansion valve, dryer, and other parts) and equipment adjustment. In other words, this type of alternative means that the same equipment is operated with an alternative refrigerant. Embodiments of this type of “alternative” include “drop-in alternative,” “nearly drop-in alternative,” and “retrofit,” in the order in which the extent of changes and adjustment necessary for replacing the first refrigerant with the second refrigerant is smaller.

[0473] The term “alternative” also includes a second type of “alternative,” which means that equipment designed for operation using the second refrigerant is operated for the same use as the existing use with the first refrigerant by using the second refrigerant. This type of alternative means that the same use is achieved with an alternative refrigerant.

[0474] In the present specification, the term “refrigerating machine” refers to machines in general that draw heat from an object or space to make its temperature lower than the temperature of ambient air, and maintain a low temperature. In other words, refrigerating machines refer to conversion machines that gain energy from the outside to do work, and that perform energy conversion, in order to transfer heat from where the temperature is lower to where the temperature is higher.

[0475] In the present specification, a refrigerant having a “WCF lower flammability” means that the most flammable composition (worst case of formulation for flammability: WCF) has a burning velocity of 10 cm/s or less according to the US ANSI/ASHRAE Standard 34-2013. Further, in the present specification, a refrigerant having “ASHRAE lower flammability” means that the burning velocity of WCF is 10 cm/s or less, that the most flammable fraction composition (worst case of fractionation for flammability: WCF), which is specified by performing a leakage test during storage, shipping, or use based on ANSI/ASHRAE 34-2013 using WCF, has a burning velocity of 10 cm/s or less, and that flammability classification according to the US ANSI/ASHRAE Standard 34-2013 is determined to be classified as “Class 2L.”

[0476] In the present specification, a refrigerant having an “RCL of x % or more” means that the refrigerant has a refrigerant concentration limit (RCL), calculated in accordance with the US ANSI/ASHRAE Standard 34-2013, of x % or more. RCL refers to a concentration limit in the air in consideration of safety factors. RCL is an index for reducing the risk of acute toxicity, suffocation, and flammability in a closed space where humans are present. RCL is determined in accordance with the ASHRAE Standard. More specifically, RCL is the lowest concentration among the acute toxicity exposure limit (ATEL), the oxygen deprivation limit (ODL), and the flammable concentration limit (FCL), which are respectively calculated in accordance with sections 7.1.1, 7.1.2, and 7.1.3 of the ASHRAE Standard.

[0477] In the present specification, temperature glide refers to an absolute value of the difference between the initial temperature and the end temperature in the phase

change process of a refrigerant composition of the present disclosure in the heat exchanger of a refrigerant system.

(4-2) Use of Refrigerant

[0478] The refrigerant according to the present disclosure can be preferably used as a working fluid in a refrigerating machine.

[0479] The composition according to the present disclosure is suitable for use as an alternative refrigerant for HFC refrigerant such as R410A, R407C and R404 etc, or HCFC refrigerant such as R22 etc.

(4-3) Refrigerant Composition

[0480] The refrigerant composition according to the present disclosure comprises at least the refrigerant according to the present disclosure, and can be used for the same use as the refrigerant according to the present disclosure. Moreover, the refrigerant composition according to the present disclosure can be further mixed with at least a refrigeration oil to thereby obtain a working fluid for a refrigerating machine.

[0481] The refrigerant composition according to the present disclosure further comprises at least one other component in addition to the refrigerant according to the present disclosure. The refrigerant composition according to the present disclosure may comprise at least one of the following other components, if necessary. As described above, when the refrigerant composition according to the present disclosure is used as a working fluid in a refrigerating machine, it is generally used as a mixture with at least a refrigeration oil. Therefore, it is preferable that the refrigerant composition according to the present disclosure does not substantially comprise a refrigeration oil. Specifically, in the refrigerant composition according to the present disclosure, the content of the refrigeration oil based on the entire refrigerant composition is preferably 0 to 1 mass %, and more preferably 0 to 0.1 mass %.

(4-3-1) Water

[0482] The refrigerant composition according to the present disclosure may contain a small amount of water. The water content of the refrigerant composition is preferably 0.1 mass % or less based on the entire refrigerant. A small amount of water contained in the refrigerant composition stabilizes double bonds in the molecules of unsaturated fluorocarbon compounds that can be present in the refrigerant, and makes it less likely that the unsaturated fluorocarbon compounds will be oxidized, thus increasing the stability of the refrigerant composition.

(4-3-2) Tracer

[0483] A tracer is added to the refrigerant composition according to the present disclosure at a detectable concentration such that when the refrigerant composition has been diluted, contaminated, or undergone other changes, the tracer can trace the changes.

[0484] The refrigerant composition according to the present disclosure may comprise a single tracer, or two or more tracers.

[0485] The tracer is not limited, and can be suitably selected from commonly used tracers. Preferably, a compound that cannot be an impurity inevitably mixed in the refrigerant of the present disclosure is selected as the tracer.

[0486] Examples of tracers include hydrofluorocarbons, hydrochlorofluorocarbons, chlorofluorocarbons, hydrochlorocarbons, fluorocarbons, deuterated hydrocarbons, deuterated hydrofluorocarbons, perfluorocarbons, fluoroethers, brominated compounds, iodinated compounds, alcohols, aldehydes, ketones, and nitrous oxide (N₂O). The tracer is particularly preferably a hydrofluorocarbon, a hydrochlorofluorocarbon, a chlorofluorocarbon, a fluorocarbon, a hydrochlorocarbon, a fluorocarbon, or a fluoroether.

[0487] The following compounds are preferable as the tracer.

FC-14 (tetrafluoromethane, CF₄)
 HCC-40 (chloromethane, CH₃Cl)
 HFC-23 (trifluoromethane, CHF₃)
 HFC-41 (fluoromethane, CH₃Cl)
 HFC-125 (pentafluoroethane, CF₃CHF₂)
 HFC-134a (1,1,1,2-tetrafluoroethane, CF₃CH₂F)
 HFC-134 (1,1,2,2-tetrafluoroethane, CHF₂CHF₂)
 HFC-143a (1,1,1-trifluoroethane, CF₃CH₃)
 HFC-143 (1,1,2-trifluoroethane, CHF₂CH₂F)
 HFC-152a (1,1-difluoroethane, CHF₂CH₃)
 HFC-152 (1,2-difluoroethane, CH₂FCH₂F)
 HFC-161 (fluoroethane, CH₃CH₂F)
 HFC-245fa (1,1,1,3,3-pentafluoropropane, CF₃CH₂CHF₂)
 HFC-236fa (1,1,1,3,3,3-hexafluoropropane, CF₃CH₂CF₃)
 HFC-236ea (1,1,1,2,3,3-hexafluoropropane, CF₃CHFCHF₂)
 HFC-227ea (1,1,1,2,3,3,3-heptafluoropropane, CF₃CHFCF₃)
 HCFC-22 (chlorodifluoromethane, CHClF₂)
 HCFC-31 (chlorofluoromethane, CH₂ClF)
 CFC-1113 (chlorotrifluoroethylene, CF₂=CClF)
 HFE-125 (trifluoromethyl-difluoromethyl ether, CF₃OCHF₂)
 HFE-134a (trifluoromethyl-fluoromethyl ether, CF₃OCH₂F)
 HFE-143a (trifluoromethyl-methyl ether, CF₃OCH₃)
 HFE-227ea (trifluoromethyl-tetrafluoroethyl ether, CF₃OCHF₂CF₃)
[0488] HFE-236fa (trifluoromethyl-trifluoroethyl ether, CF₃OCH₂CF₃)

[0489] The tracer compound may be present in the refrigerant composition at a total concentration of about 10 parts per million (ppm) to about 1000 ppm. Preferably, the tracer compound is present in the refrigerant composition at a total concentration of about 30 ppm to about 500 ppm, and most preferably, the tracer compound is present at a total concentration of about 50 ppm to about 300 ppm.

(4-3-3) Ultraviolet Fluorescent Dye

[0490] The refrigerant composition according to the present disclosure may comprise a single ultraviolet fluorescent dye, or two or more ultraviolet fluorescent dyes.

[0491] The ultraviolet fluorescent dye is not limited, and can be suitably selected from commonly used ultraviolet fluorescent dyes.

[0492] Examples of ultraviolet fluorescent dyes include naphthalimide, coumarin, anthracene, phenanthrene, xanthene, thioxanthene, naphthoxanthene, fluorescein, and derivatives thereof. The ultraviolet fluorescent dye is particularly preferably either naphthalimide or coumarin, or both.

(4-3-4) Stabilizer

[0493] The refrigerant composition according to the present disclosure may comprise a single stabilizer, or two or more stabilizers.

[0494] The stabilizer is not limited, and can be suitably selected from commonly used stabilizers.

[0495] Examples of stabilizers include nitro compounds, ethers, and amines.

[0496] Examples of nitro compounds include aliphatic nitro compounds, such as nitromethane and nitroethane; and aromatic nitro compounds, such as nitro benzene and nitro styrene.

[0497] Examples of ethers include 1,4-dioxane.

[0498] Examples of amines include 2,2,3,3,3-pentafluoropropylamine and diphenylamine.

[0499] Examples of stabilizers also include butylhydroxyxylene and benzotriazole.

[0500] The content of the stabilizer is not limited. Generally, the content of the stabilizer is preferably 0.01 to 5 mass %, and more preferably 0.05 to 2 mass %, based on the entire refrigerant.

(4-3-5) Polymerization Inhibitor

[0501] The refrigerant composition according to the present disclosure may comprise a single polymerization inhibitor, or two or more polymerization inhibitors.

[0502] The polymerization inhibitor is not limited, and can be suitably selected from commonly used polymerization inhibitors.

[0503] Examples of polymerization inhibitors include 4-methoxy-1-naphthol, hydroquinone, hydroquinone methyl ether, dimethyl-t-butylphenol, 2,6-di-tert-butyl-p-cresol, and benzotriazole.

[0504] The content of the polymerization inhibitor is not limited. Generally, the content of the polymerization inhibitor is preferably 0.01 to 5 mass %, and more preferably 0.05 to 2 mass %, based on the entire refrigerant.

(4-4) Refrigeration Oil-Containing Working Fluid

[0505] The refrigeration oil-containing working fluid according to the present disclosure comprises at least the refrigerant or refrigerant composition according to the present disclosure and a refrigeration oil, for use as a working fluid in a refrigerating machine. Specifically, the refrigeration oil-containing working fluid according to the present disclosure is obtained by mixing a refrigeration oil used in a compressor of a refrigerating machine with the refrigerant or the refrigerant composition. The refrigeration oil-containing working fluid generally comprises 10 to 50 mass % of refrigeration oil.

[0506] As the refrigeration oil contained in the refrigeration oil-containing working fluid, one kind of the refrigeration oil described in the column of (2) Refrigerating oil may be contained alone, or two or more kinds thereof may be contained. The refrigerating oil may contain the additives described in the column of (2-3) Additive. Hereinafter, the refrigerants A to E, which are the refrigerants used in the present embodiment, will be described in detail.

[0507] In addition, each description of the following refrigerant A, refrigerant B, refrigerant C, refrigerant D, and refrigerant E is each independent. The alphabet which shows a point or a line segment, the number of an Examples, and the number of a comparative examples are all independent

of each other among the refrigerant A, the refrigerant B, the refrigerant C, the refrigerant D, and the refrigerant E. For example, the first embodiment of the refrigerant A and the first embodiment of the refrigerant B are different embodiment from each other.

(5-1) Refrigerant A

[0508] The refrigerant A according to the present disclosure is a mixed refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and 2,3,3,3-tetrafluoro-1-propene (R1234yf).

[0509] The refrigerant A according to the present disclosure has various properties that are desirable as an R410A-alternative refrigerant, i.e., a refrigerating capacity and a coefficient of performance that are equivalent to those of R410A, and a sufficiently low GWP.

[0510] The refrigerant A according to the present disclosure is a composition comprising HFO-1132(E) and R1234yf, and optionally further comprising HFO-1123, and may further satisfy the following requirements. This refrigerant also has various properties desirable as an alternative refrigerant for R410A; i.e., it has a refrigerating capacity and a coefficient of performance that are equivalent to those of R410A, and a sufficiently low GWP.

Requirements

[0511] Preferable refrigerant A is as follows:

[0512] When the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum in the refrigerant is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132 (E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments AA', A'B, BD, DC', C'C, CO, and OA that connect the following 7 points: point A (68.6, 0.0, 31.4), point A' (30.6, 30.0, 39.4), point B (0.0, 58.7, 41.3), point D (0.0, 80.4, 19.6), point C' (19.5, 70.5, 10.0), point C (32.9, 67.1, 0.0), and point O (100.0, 0.0, 0.0),

or on the above line segments (excluding the points on the line CO);

[0513] the line segment AA' is represented by coordinates (x, $0.0016x^2 - 0.9473x + 57.497$, $-0.0016x^2 - 0.0527x + 42.503$),

[0514] the line segment A'B is represented by coordinates (x, $0.0029x^2 - 1.0268x + 58.7$, $-0.0029x^2 + 0.0268x + 41.3$),

[0515] the line segment DC' is represented by coordinates (x, $0.0082x^2 - 0.6671x + 80.4$, $-0.0082x^2 - 0.3329x + 19.6$),

[0516] the line segment C'C is represented by coordinates (x, $0.0067x^2 - 0.6034x + 79.729$, $-0.0067x^2 - 0.3966x + 20.271$), and

[0517] the line segments BD, CO, and OA are straight lines.

[0518] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP of 92.5% or more relative to that of R410A.

[0519] When the mass % of HFO-1132(E), HFO-1123, and R1234yf, based on their sum in the refrigerant A according to the present disclosure is respectively repre-

sented by x , y , and z , the refrigerant is preferably a refrigerant wherein coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within a figure surrounded by line segments GI, IA, AA', A'B, BD, DC', C'C, and CG that connect the following 8 points:

point G (72.0, 28.0, 0.0),

point I (72.0, 0.0, 28.0),

point A (68.6, 0.0, 31.4),

point A' (30.6, 30.0, 39.4),

point B (0.0, 58.7, 41.3),

point D (0.0, 80.4, 19.6),

point C' (19.5, 70.5, 10.0), and

point C (32.9, 67.1, 0.0),

or on the above line segments (excluding the points on the line segment CG);

[0520] the line segment AA' is represented by coordinates $(x, 0.0016x^2-0.9473x+57.497, -0.0016x^2-0.0527x+42.503)$,

[0521] the line segment A'B is represented by coordinates $(x, 0.0029x^2-1.0268x+58.7, -0.0029x^2+0.0268x+41.3)$,

[0522] the line segment DC' is represented by coordinates $(x, 0.0082x^2-0.6671x+80.4, -0.0082x^2-0.3329x+19.6)$,

[0523] the line segment C'C is represented by coordinates $(x, 0.0067x^2-0.6034x+79.729, -0.0067x^2-0.3966x+20.271)$, and

[0524] the line segments GI, IA, BD, and CG are straight lines.

[0525] When the requirements above are satisfied, the refrigerant A according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP of 92.5% or more relative to that of R410A; furthermore, the refrigerant A has a WCF lower flammability according to the ASHRAE Standard (the WCF composition has a burning velocity of 10 cm/s or less).

[0526] When the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum in the refrigerant according to the present disclosure is respectively represented by x , y , and z , the refrigerant is preferably a refrigerant wherein coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments JP, PN, NK, KA', A'B, BD, DC', C'C, and CJ that connect the following 9 points:

point J (47.1, 52.9, 0.0),

point P (55.8, 42.0, 2.2),

point N (68.6, 16.3, 15.1),

point K (61.3, 5.4, 33.3),

point A' (30.6, 30.0, 39.4),

point B (0.0, 58.7, 41.3),

point D (0.0, 80.4, 19.6),

point C' (19.5, 70.5, 10.0), and

point C (32.9, 67.1, 0.0),

or on the above line segments (excluding the points on the line segment CJ);

[0527] the line segment PN is represented by coordinates $(x, -0.1135x^2+12.112x-280.43, 0.1135x^2-13.112x+380.43)$,

[0528] the line segment NK is represented by coordinates $(x, 0.2421x^2-29.955x+931.91, -0.2421x^2+28.955x-831.91)$,

[0529] the line segment KA' is represented by coordinates $(x, 0.0016x^2-0.9473x+57.497, -0.0016x^2-0.0527x+42.503)$,

[0530] the line segment A'B is represented by coordinates $(x, 0.0029x^2-1.0268x+58.7, -0.0029x^2+0.0268x+41.3)$,

[0531] the line segment DC' is represented by coordinates $(x, 0.0082x^2-0.6671x+80.4, -0.0082x^2-0.3329x+19.6)$,

[0532] the line segment C'C is represented by coordinates $(x, 0.0067x^2-0.6034x+79.729, -0.0067x^2-0.3966x+20.271)$, and

[0533] the line segments JP, BD, and CG are straight lines.

[0534] When the requirements above are satisfied, the refrigerant A according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP of 92.5% or more relative to that of R410A; furthermore, the refrigerant exhibits a lower flammability (Class 2L) according to the ASHRAE Standard (the WCF composition and the WCF composition have a burning velocity of 10 cm/s or less).

[0535] When the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum in the refrigerant according to the present disclosure is respectively represented by x , y , and z , the refrigerant is preferably a refrigerant wherein coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments JP, PL, LM, MA', A'B, BD, DC', C'C, and CJ that connect the following 9 points:

point J (47.1, 52.9, 0.0),

point P (55.8, 42.0, 2.2),

point L (63.1, 31.9, 5.0),

point M (60.3, 6.2, 33.5),

point A' (30.6, 30.0, 39.4),

point B (0.0, 58.7, 41.3),

point D (0.0, 80.4, 19.6),

point C' (19.5, 70.5, 10.0), and

point (32.9, 67.1, 0.0),

or on the above line segments (excluding the points on the line segment CJ);

[0536] the line segment PL is represented by coordinates $(x, -0.1135x^2+12.112x-280.43, 0.1135x^2-13.112x+380.43)$,

[0537] the line segment MA' is represented by coordinates $(x, 0.0016x^2-0.9473x+57.497, -0.0016x^2-0.0527x+42.503)$,

[0538] the line segment A'B is represented by coordinates $(x, 0.0029x^2-1.0268x+58.7, -0.0029x^2+0.0268x+41.3)$,

[0539] the line segment DC' is represented by coordinates $(x, 0.0082x^2-0.6671x+80.4, -0.0082x^2-0.3329x+19.6)$,

[0540] the line segment C'C is represented by coordinates $(x, 0.0067x^2-0.6034x+79.729, -0.0067x^2-0.3966x+20.271)$, and

[0541] the line segments JP, LM, BD, and CG are straight lines.

[0542] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP of 92.5% or more relative to that of R410A; furthermore, the refrigerant has an RCL of 40 g/m³ or more.

[0543] When the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum in the refrigerant A according to the present disclosure is respectively represented by x , y , and z , the refrigerant is preferably a refrigerant wherein coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by

line segments PL, LM, MA', A'B, BF, FT, and TP that connect the following 7 points:

point P (55.8, 42.0, 2.2),
point L (63.1, 31.9, 5.0),
point M (60.3, 6.2, 33.5),
point A' (30.6, 30.0, 39.4),
point B (0.0, 58.7, 41.3),
point F (0.0, 61.8, 38.2), and
point T (35.8, 44.9, 19.3),

or on the above line segments (excluding the points on the line segment BF);

[0544] the line segment PL is represented by coordinates $(x, -0.1135x^2+12.112x-280.43, 0.1135x^2-13.112x+380.43)$,

[0545] the line segment MA' is represented by coordinates $(x, 0.0016x^2-0.9473x+57.497, -0.0016x^2-0.0527x+42.503)$,

[0546] the line segment A'B is represented by coordinates $(x, 0.0029x^2-1.0268x+58.7, -0.0029x^2+0.0268x+41.3)$,

[0547] the line segment FT is represented by coordinates $(x, 0.0078x^2-0.7501x+61.8, -0.0078x^2-0.2499x+38.2)$,

[0548] the line segment TP is represented by coordinates $(x, 0.00672x^2-0.7607x+63.525, -0.00672x^2-0.2393x+36.475)$, and

[0549] the line segments LM and BF are straight lines.

[0550] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP of 95% or more relative to that of R410A; furthermore, the refrigerant has an RCL of 40 g/m³ or more.

[0551] The refrigerant A according to the present disclosure is preferably a refrigerant wherein when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum in the refrigerant is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments PL, LQ, QR, and RP that connect the following 4 points:

point P (55.8, 42.0, 2.2),
point L (63.1, 31.9, 5.0),
point Q (62.8, 29.6, 7.6), and
point R (49.8, 42.3, 7.9),

or on the above line segments;

[0552] the line segment PL is represented by coordinates $(x, -0.1135x^2+12.112x-280.43, 0.1135x^2-13.112x+380.43)$,

[0553] the line segment RP is represented by coordinates $(x, 0.00672x^2-0.7607x+63.525, -0.00672x^2-0.2393x+36.475)$, and

[0554] the line segments LQ and QR are straight lines.

[0555] When the requirements above are satisfied, the refrigerant according to the present disclosure has a COP of 95% or more relative to that of R410A, and an RCL of 40 g/m³ or more, furthermore, the refrigerant has a condensation temperature glide of 1° C. or less.

[0556] The refrigerant A according to the present disclosure is preferably a refrigerant wherein when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum in the refrigerant is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is

100 mass % are within the range of a figure surrounded by line segments SM, MA', A'B, BF, FT, and TS that connect the following 6 points:

point S (62.6, 28.3, 9.1),
point M (60.3, 6.2, 33.5),
point A' (30.6, 30.0, 39.4),
point B (0.0, 58.7, 41.3),
point F (0.0, 61.8, 38.2), and
point T (35.8, 44.9, 19.3),

or on the above line segments,

[0557] the line segment MA' is represented by coordinates $(x, 0.0016x^2-0.9473x+57.497, -0.0016x^2-0.0527x+42.503)$,

[0558] the line segment A'B is represented by coordinates $(x, 0.0029x^2-1.0268x+58.7, -0.0029x^2+0.0268x+41.3)$,

[0559] the line segment FT is represented by coordinates $(x, 0.0078x^2-0.7501x+61.8, -0.0078x^2-0.2499x+38.2)$,

[0560] the line segment TS is represented by coordinates $(x, -0.0017x^2-0.7869x+70.888, -0.0017x^2-0.2131x+29.112)$, and

[0561] the line segments SM and BF are straight lines.

[0562] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to that of R410A, a COP of 95% or more relative to that of R410A, and an RCL of 40 g/m³ or more furthermore, the refrigerant has a discharge pressure of 105% or more relative to that of R410A.

[0563] The refrigerant A according to the present disclosure is preferably a refrigerant wherein when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum in the refrigerant is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments Od, dg, gh, and hO that connect the following 4 points:

point d (87.6, 0.0, 12.4),
point g (18.2, 55.1, 26.7),
point h (56.7, 43.3, 0.0), and
point o (100.0, 0.0, 0.0),

or on the line segments Od, dg, gh, and hO (excluding the points o and h);

[0564] the line segment dg is represented by coordinates $(0.0047y^2-1.5177y+87.598, y, -0.0047y^2+0.5177y+12.402)$,

[0565] the line segment gh is represented by coordinates $(-0.0134z^2-1.0825z+56.692, 0.0134z^2+0.0825z+43.308, z)$, and

[0566] the line segments hO and Od are straight lines.

[0567] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 92.5% or more relative to that of R410A, and a COP ratio of 92.5% or more relative to that of R410A.

[0568] The refrigerant A according to the present disclosure is preferably a refrigerant wherein

[0569] when the mass % of HFO-1132(E), HFO-1123, and R1234yf, based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments lg, gh, hi, and il that connect the following 4 points:

point l (72.5, 10.2, 17.3),
 point g (18.2, 55.1, 26.7),
 point h (56.7, 43.3, 0.0), and
 point i (72.5, 27.5, 0.0) or
 on the line segments lg, gh, and il (excluding the points h and i);

[0570] the line segment lg is represented by coordinates $(0.0047y^2 - 1.5177y + 87.598, y, -0.0047y^2 + 0.5177y + 12.402)$,

[0571] the line gh is represented by coordinates $(-0.0134z^2 - 1.0825z + 56.692, 0.0134z^2 + 0.0825z + 43.308, z)$, and

[0572] the line segments hi and il are straight lines.

[0573] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 92.5% or more relative to that of R410A, and a COP ratio of 92.5% or more relative to that of R410A; furthermore, the refrigerant has a lower flammability (Class 2L) according to the ASHRAE Standard.

[0574] The refrigerant A according to the present disclosure is preferably a refrigerant wherein

[0575] when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments Od, de, ef, and fO that connect the following 4 points:

point d (87.6, 0.0, 12.4),
 point e (31.1, 42.9, 26.0),
 point f (65.5, 34.5, 0.0), and
 point O (100.0, 0.0, 0.0),

or on the line segments Od, de, and ef (excluding the points O and f);

[0576] the line segment de is represented by coordinates $(0.0047y^2 - 1.5177y + 87.598, y, -0.0047y^2 + 0.5177y + 12.402)$,

[0577] the line segment ef is represented by coordinates $(-0.0064z^2 - 1.1565z + 65.501, 0.0064z^2 + 0.1565z + 34.499, z)$, and

[0578] the line segments fO and Od are straight lines.

[0579] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 93.5% or more relative to that of R410A, and a COP ratio of 93.5% or more relative to that of R410A.

[0580] The refrigerant A according to the present disclosure is preferably a refrigerant wherein

[0581] when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments le, ef, fi, and il that connect the following 4 points:

point l (72.5, 10.2, 17.3),
 point e (31.1, 42.9, 26.0),
 point f (65.5, 34.5, 0.0), and
 point i (72.5, 27.5, 0.0),

or on the line segments le, ef, and il (excluding the points f and i);

[0582] the line segment le is represented by coordinates $(0.0047y^2 - 1.5177y + 87.598, y, -0.0047y^2 + 0.5177y + 12.402)$,

[0583] the line segment ef is represented by coordinates $(-0.0134z^2 - 1.0825z + 56.692, 0.0134z^2 + 0.0825z + 43.308, z)$, and

[0584] the line segments fi and il are straight lines.

[0585] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 93.5% or more relative to that of R410A, and a COP ratio of 93.5% or more relative to that of R410A; furthermore, the refrigerant has a lower flammability (Class 2L) according to the ASHRAE Standard.

[0586] The refrigerant A according to the present disclosure is preferably a refrigerant wherein when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum is respectively represented by x, y, and z,

[0587] coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments Oa, ab, bc, and cO that connect the following 4 points:

point a (93.4, 0.0, 6.6),
 point b (55.6, 26.6, 17.8),
 point c (77.6, 22.4, 0.0), and
 point O (100.0, 0.0, 0.0),

or on the line segments Oa, ab, and bc (excluding the points O and c);

[0588] the line segment ab is represented by coordinates $(0.0052y^2 - 1.5588y + 93.385, y, -0.0052y^2 + 0.5588y + 6.615)$,

[0589] the line segment bc is represented by coordinates $(-0.0032z^2 - 1.1791z + 77.593, 0.0032z^2 + 0.1791z + 22.407, z)$, and

[0590] the line segments cO and Oa are straight lines.

[0591] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 95% or more relative to that of R410A, and a COP ratio of 95% or more relative to that of R410A.

[0592] The refrigerant A according to the present disclosure is preferably a refrigerant wherein

[0593] when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum is respectively represented by x, y, and z,

[0594] coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments kb, bj, and jk that connect the following 3 points:

point k (72.5, 14.1, 13.4),
 point b (55.6, 26.6, 17.8), and
 point j (72.5, 23.2, 4.3),

or on the line segments kb, bj, and jk;

[0595] the line segment kb is represented by coordinates $(0.0052y^2 - 1.5588y + 93.385, y, -0.0052y^2 + 0.5588y + 6.615)$,

[0596] the line segment bj is represented by coordinates $(-0.0032z^2 - 1.1791z + 77.593, 0.0032z^2 + 0.1791z + 22.407, z)$, and

[0597] the line segment jk is a straight line.

[0598] When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 95% or more relative to that of R410A, and a COP ratio of 95% or more relative to that of R410A; furthermore, the refrigerant has a lower flammability (Class 2L) according to the ASHRAE Standard.

[0599] The refrigerant according to the present disclosure may further comprise other additional refrigerants in addition to HFO-1132(E), HFO-1123, and R1234yf, as long as the above properties and effects are not impaired. In this respect, the refrigerant according to the present disclosure preferably comprises HFO-1132(E), HFO-1123, and R1234yf in a total amount of 99.5 mass % or more, more preferably 99.75 mass % or more, and still more preferably 99.9 mass % or more, based on the entire refrigerant.

[0600] The refrigerant according to the present disclosure may comprise HFO-1132(E), HFO-1123, and R1234yf in a total amount of 99.5 mass % or more, 99.75 mass % or more, or 99.9 mass % or more, based on the entire refrigerant.

[0601] Additional refrigerants are not particularly limited and can be widely selected. The mixed refrigerant may contain one additional refrigerant, or two or more additional refrigerants.

(Examples of Refrigerant A)

[0602] The present disclosure is described in more detail below with reference to Examples of refrigerant A. However, refrigerant A is not limited to the Examples.

[0603] The GWP of R1234yf and a composition consisting of a mixed refrigerant R410A (R32=50%/R125=50%)

was evaluated based on the values stated in the Intergovernmental Panel on Climate Change (IPCC), fourth report. The GWP of HFO-1132(E), which was not stated therein, was assumed to be 1 from HFO-1132a (GWP=1 or less) and HFO-1123 (GWP=0.3, described in Patent Literature 1). The refrigerating capacity of R410A and compositions each comprising a mixture of HFO-1132(E), HFO-1123, and R1234yf was determined by performing theoretical refrigeration cycle calculations for the mixed refrigerants using the National Institute of Science and Technology (NIST) and Reference Fluid Thermodynamic and Transport Properties Database (Refprop 9.0) under the following conditions.

[0604] Further, the RCL of the mixture was calculated with the LFL of HFO-1132(E) being 4.7 vol. %, the LFL of HFO-1123 being 10 vol. %, and the LFL of R1234yf being 6.2 vol. %, in accordance with the ASHRAE Standard 34-2013.

Evaporating temperature: 5° C.

Condensation temperature: 45° C.

Degree of superheating: 5 K

Degree of subcooling: 5 K

Compressor efficiency: 70%

[0605] Tables 1 to 34 show these values together with the GWP of each mixed refrigerant.

TABLE 1

Item	Unit	Comp. Ex. 1	Comp.		Exam-ple 1	Exam-ple 2 A'	Exam-ple 3	Comp. Ex. 4 B
			Ex. 2 O	Ex. 3 A				
HFO-1132(E)	mass %	R410A	100.0	68.6	49.0	30.6	14.1	0.0
HFO-1123	mass %		0.0	0.0	14.9	30.0	44.8	58.7
R1234yf	mass %		0.0	31.4	36.1	39.4	41.1	41.3
GWP	—	2088	1	2	2	2	2	2
COP ratio	% (relative to 410A)	100	99.7	100.0	98.6	97.3	96.3	95.5
Refrigerating capacity ratio	% (relative to 410A)	100	98.3	85.0	85.0	85.0	85.0	85.0
Condensation glide	° C.	0.1	0.00	1.98	3.36	4.46	5.15	5.35
Discharge pressure	% (relative to 410A)	100.0	99.3	87.1	88.9	90.6	92.1	93.2
RCL	g/m ³	—	30.7	37.5	44.0	52.7	64.0	78.6

TABLE 2

Item	Unit	Comp. Ex. 5 C	Exam-ple 4	Exam-ple 5		Comp. Ex. 6 D	Comp. Ex. 7 E	Exam-ple 7 E'	Comp. Ex. 8 F
				Ex. 5 C'	Exam-ple 6				
HFO-1132(E)	mass %	32.9	26.6	19.5	10.9	0.0	58.0	23.4	0.0
HFO-1123	mass %	67.1	68.4	70.5	74.1	80.4	42.0	48.5	61.8
R1234yf	mass %	0.0	5.0	10.0	15.0	19.6	0.0	28.1	38.2
GWP	—	1	1	1	1	2	1	2	2
COP ratio	% (relative to 410A)	92.5	92.5	92.5	92.5	92.5	95.0	95.0	95.0
Refrigerating capacity ratio	% (relative to 410A)	107.4	105.2	102.9	100.5	97.9	105.0	92.5	86.9
Condensation glide	° C.	0.16	0.52	0.94	1.42	1.90	0.42	3.16	4.80
Discharge pressure	% (relative to 410A)	119.5	117.4	115.3	113.0	115.9	112.7	101.0	95.8
RCL	g/m ³	53.5	57.1	62.0	69.1	81.3	41.9	46.3	79.0

TABLE 3

Item	Unit	Comp. Ex. 9 J	Example 8 P	Example 9 L	Example 10 N	Example 11 N'	Example 12 K
HFO-1132(E)	mass %	47.1	55.8	63.1	68.6	65.0	61.3
HFO-1123	mass %	52.9	42.0	31.9	16.3	7.7	5.4
R1234yf	mass %	0.0	2.2	5.0	15.1	27.3	33.3
GWP	—	1	1	1	1	2	2
COP ratio	% (relative to 410A)	93.8	95.0	96.1	97.9	99.1	99.5
Refrigerating capacity ratio	% (relative to 410A)	106.2	104.1	101.6	95.0	88.2	85.0
Condensation glide	° C.	0.31	0.57	0.81	1.41	2.11	2.51
Discharge pressure	% (relative to 410A)	115.8	111.9	107.8	99.0	91.2	87.7
RCL	g/m ³	46.2	42.6	40.0	38.0	38.7	39.7

TABLE 4

Item	Unit	Example 13 L	Example 14 M	Example 15 Q	Example 16 R	Example 17 S	Example 18 S'	Example 19 T
HFO-1132(E)	mass %	63.1	60.3	62.8	49.8	62.6	50.0	35.8
HFO-1123	mass %	31.9	6.2	29.6	42.3	28.3	35.8	44.9
R1234yf	mass %	5.0	33.5	7.6	7.9	9.1	14.2	19.3
GWP	—	1	2	1	1	1	1	2
COP ratio	% (relative to 410A)	96.1	99.4	96.4	95.0	96.6	95.8	95.0
Refrigerating capacity ratio	% (relative to 410A)	101.6	85.0	100.2	101.7	99.4	98.1	96.7
Condensation glide	° C.	0.81	2.58	1.00	1.00	1.10	1.55	2.07
Discharge pressure	% (relative to 410A)	107.8	87.9	106.0	109.6	105.0	105.0	105.0
RCL	g/m ³	40.0	40.0	40.0	44.8	40.0	44.4	50.8

TABLE 5

Item	Unit	Comp. Ex. 10 G	Example 20 H	Example 21 I
HFO-1132(E)	mass %	72.0	72.0	72.0
HFO-1123	mass %	28.0	14.0	0.0
R1234yf	mass %	0.0	14.0	28.0
GWP	—	1	1	2
COP ratio	% (relative to 410A)	96.6	98.2	99.9

TABLE 5-continued

Item	Unit	Comp. Ex. 10 G	Example 20 H	Example 21 I
Refrigerating capacity ratio	% (relative to 410A)	103.1	95.1	86.6
Condensation glide	° C.	0.46	1.27	1.71
Discharge pressure	% (relative to 410A)	108.4	98.7	88.6
RCL	g/m ³	37.4	37.0	36.6

TABLE 6

Item	Unit	Comp. Ex. 11	Comp. Ex. 12	Example 22	Example 23	Example 24	Example 25	Example 26	Comp. Ex. 13
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0
HFO-1123	mass %	85.0	75.0	65.0	55.0	45.0	35.0	25.0	15.0
R1234yf	mass %	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
GWP	—	1	1	1	1	1	1	1	1
COP ratio	% (relative to 410A)	91.4	92.0	92.8	93.7	94.7	95.8	96.9	98.0
Refrigerating capacity ratio	% (relative to 410A)	105.7	105.5	105.0	104.3	103.3	102.0	100.6	99.1
Condensation glide	° C.	0.40	0.46	0.55	0.66	0.75	0.80	0.79	0.67
Discharge pressure	% (relative to 410A)	120.1	118.7	116.7	114.3	111.6	108.7	105.6	102.5
RCL	g/m ³	71.0	61.9	54.9	49.3	44.8	41.0	37.8	35.1

TABLE 7

Item	Unit	Comp. Ex. 14	Example 27	Example 28	Example 29	Example 30	Example 31	Example 32	Comp. Ex. 15
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0
HFO-1123	mass %	80.0	70.0	60.0	50.0	40.0	30.0	20.0	10.0
R1234yf	mass %	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
GWP	—	1	1	1	1	1	1	1	1
COP ratio	% (relative to 410A)	91.9	92.5	93.3	94.3	95.3	96.4	97.5	98.6
Refrigerating capacity ratio	% (relative to 410A)	103.2	102.9	102.4	101.5	100.5	99.2	97.8	96.2
Condensation glide	° C.	0.87	0.94	1.03	1.12	1.18	1.18	1.09	0.88
Discharge pressure	% (relative to 410A)	116.7	115.2	113.2	110.8	108.1	105.2	102.1	99.0
RCL	g/m ³	70.5	61.6	54.6	49.1	44.6	40.8	37.7	35.0

TABLE 8

Item	Unit	Comp. Ex. 16	Example 33	Example 34	Example 35	Example 36	Example 37	Example 38	Comp. Ex. 17
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0
HFO-1123	mass %	75.0	65.0	55.0	45.0	35.0	25.0	15.0	5.0
R1234yf	mass %	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
GWP	—	1	1	1	1	1	1	1	1
COP ratio	% (relative to 410A)	92.4	93.1	93.9	94.8	95.9	97.0	98.1	99.2
Refrigerating capacity ratio	% (relative to 410A)	100.5	100.2	99.6	98.7	97.7	96.4	94.9	93.2
Condensation glide	° C.	1.41	1.49	1.56	1.62	1.63	1.55	1.37	1.05
Discharge pressure	% (relative to 410A)	113.1	111.6	109.6	107.2	104.5	101.6	98.6	95.5
RCL	g/m ³	70.0	61.2	54.4	48.9	44.4	40.7	37.5	34.8

TABLE 9

Item	Unit	Example 39	Example 40	Example 41	Example 42	Example 43	Example 44	Example 45
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0
HFO-1123	mass %	70.0	60.0	50.0	40.0	30.0	20.0	10.0
R1234yf	mass %	20.0	20.0	20.0	20.0	20.0	20.0	20.0
GWP	—	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	93.0	93.7	94.5	95.5	96.5	97.6	98.7
Refrigerating capacity ratio	% (relative to 410A)	97.7	97.4	96.8	95.9	94.7	93.4	91.9
Condensation glide	° C.	2.03	2.09	2.13	2.14	2.07	1.91	1.61
Discharge pressure	% (relative to 410A)	109.4	107.9	105.9	103.5	100.8	98.0	95.0
RCL	g/m ³	69.6	60.9	54.1	48.7	44.2	40.5	37.4

TABLE 10

Item	Unit	Example 46	Example 47	Example 48	Example 49	Example 50	Example 51	Example 52
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0
HFO-1123	mass %	65.0	55.0	45.0	35.0	25.0	15.0	5.0
R1234yf	mass %	25.0	25.0	25.0	25.0	25.0	25.0	25.0
GWP	—	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	93.6	94.3	95.2	96.1	97.2	98.2	99.3
Refrigerating capacity ratio	% (relative to 410A)	94.8	94.5	93.8	92.9	91.8	90.4	88.8
Condensation glide	° C.	2.71	2.74	2.73	2.66	2.50	2.22	1.78

TABLE 10-continued

Item	Unit	Example 46	Example 47	Example 48	Example 49	Example 50	Example 51	Example 52
Discharge pressure	% (relative to 410A)	105.5	104.0	102.1	99.7	97.1	94.3	91.4
RCL	g/m ³	69.1	60.5	53.8	48.4	44.0	40.4	37.3

TABLE 11

Item	Unit	Example 53	Example 54	Example 55	Example 56	Example 57	Example 58
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0
HFO-1123	mass %	60.0	50.0	40.0	30.0	20.0	10.0
R1234yf	mass %	30.0	30.0	30.0	30.0	30.0	30.0
GWP	—	2	2	2	2	2	2
COP ratio	% (relative to 410A)	94.3	95.0	95.9	96.8	97.8	98.9
Refrigerating capacity ratio	% (relative to 410A)	91.9	91.5	90.8	89.9	88.7	87.3
Condensation glide	° C.	3.46	3.43	3.35	3.18	2.90	2.47
Discharge pressure	% (relative to 410A)	101.6	100.1	98.2	95.9	93.3	90.6
RCL	g/m ³	68.7	60.2	53.5	48.2	43.9	40.2

TABLE 12

Item	Unit	Example 59	Example 60	Example 61	Example 62	Example 63	Comp. Ex. 18
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0
HFO-1123	mass %	55.0	45.0	35.0	25.0	15.0	5.0
R1234yf	mass %	35.0	35.0	35.0	35.0	35.0	35.0
GWP	—	2	2	2	2	2	2
COP ratio	% (relative to 410A)	95.0	95.8	96.6	97.5	98.5	99.6
Refrigerating capacity ratio	% (relative to 410A)	88.9	88.5	87.8	86.8	85.6	84.1
Condensation glide	° C.	4.24	4.15	3.96	3.67	3.24	2.64
Discharge pressure	% (relative to 410A)	97.6	96.1	94.2	92.0	89.5	86.8
RCL	g/m ³	68.2	59.8	53.2	48.0	43.7	40.1

TABLE 13

Item	Unit	Example 64	Example 65	Comp. Ex. 19	Comp. Ex. 20	Comp. Ex. 21
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0
HFO-1123	mass %	50.0	40.0	30.0	20.0	10.0
R1234yf	mass %	40.0	40.0	40.0	40.0	40.0
GWP	—	2	2	2	2	2
COP ratio	% (relative to 410A)	95.9	96.6	97.4	98.3	99.2
Refrigerating capacity ratio	% (relative to 410A)	85.8	85.4	84.7	83.6	82.4
Condensation glide	° C.	5.05	4.85	4.55	4.10	3.50
Discharge pressure	% (relative to 410A)	93.5	92.1	90.3	88.1	85.6
RCL	g/m ³	67.8	59.5	53.0	47.8	43.5

TABLE 14

Item	Unit	Example 66	Example 67	Example 68	Example 69	Example 70	Example 71	Example 72	Example 73
HFO-1132(E)	mass %	54.0	56.0	58.0	62.0	52.0	54.0	56.0	58.0
HFO-1123	mass %	41.0	39.0	37.0	33.0	41.0	39.0	37.0	35.0
R1234yf	mass %	5.0	5.0	5.0	5.0	7.0	7.0	7.0	7.0
GWP	—	1	1	1	1	1	1	1	1
COP ratio	% (relative to 410A)	95.1	95.3	95.6	96.0	95.1	95.4	95.6	95.8
Refrigerating capacity ratio	% (relative to 410A)	102.8	102.6	102.3	101.8	101.9	101.7	101.5	101.2
Condensation glide	° C.	0.78	0.79	0.80	0.81	0.93	0.94	0.95	0.95
Discharge pressure	% (relative to 410A)	110.5	109.9	109.3	108.1	109.7	109.1	108.5	107.9
RCL	g/m ³	43.2	42.4	41.7	40.3	43.9	43.1	42.4	41.6

TABLE 15

Item	Unit	Example 74	Example 75	Example 76	Example 77	Example 78	Example 79	Example 80	Example 81
HFO-1132(E)	mass %	60.0	62.0	61.0	58.0	60.0	62.0	52.0	54.0
HFO-1123	mass %	33.0	31.0	29.0	30.0	28.0	26.0	34.0	32.0
R1234yf	mass %	7.0	7.0	10.0	12.0	12.0	12.0	14.0	14.0
GWP	—	1	1	1	1	1	1	1	1
COP ratio	% (relative to 410A)	96.0	96.2	96.5	96.4	96.6	96.8	96.0	96.2
Refrigerating capacity ratio	% (relative to 410A)	100.9	100.7	99.1	98.4	98.1	97.8	98.0	97.7
Condensation glide	° C.	0.95	0.95	1.18	1.34	1.33	1.32	1.53	1.53
Discharge pressure	% (relative to 410A)	107.3	106.7	104.9	104.4	103.8	103.2	104.7	104.1
RCL	g/m ³	40.9	40.3	40.5	41.5	40.8	40.1	43.6	42.9

TABLE 16

Item	Unit	Example 82	Example 83	Example 84	Example 85	Example 86	Example 87	Example 88	Example 89
HFO-1132(E)	mass %	56.0	58.0	60.0	48.0	50.0	52.0	54.0	56.0
HFO-1123	mass %	30.0	28.0	26.0	36.0	34.0	32.0	30.0	28.0
R1234yf	mass %	14.0	14.0	14.0	16.0	16.0	16.0	16.0	16.0
GWP	—	1	1	1	1	1	1	1	1
COP ratio	% (relative to 410A)	96.4	96.6	96.9	95.8	96.0	96.2	96.4	96.7
Refrigerating capacity ratio	% (relative to 410A)	97.5	97.2	96.9	97.3	97.1	96.8	96.6	96.3
Condensation glide	° C.	1.51	1.50	1.48	1.72	1.72	1.71	1.69	1.67
Discharge pressure	% (relative to 410A)	103.5	102.9	102.3	104.3	103.8	103.2	102.7	102.1
RCL	g/m ³	42.1	41.4	40.7	45.2	44.4	43.6	42.8	42.1

TABLE 17

Item	Unit	Example 90	Example 91	Example 92	Example 93	Example 94	Example 95	Example 96	Example 97
HFO-1132(E)	mass %	58.0	60.0	42.0	44.0	46.0	48.0	50.0	52.0
HFO-1123	mass %	26.0	24.0	40.0	38.0	36.0	34.0	32.0	30.0
R1234yf	mass %	16.0	16.0	18.0	18.0	18.0	18.0	18.0	18.0
GWP	—	1	1	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.9	97.1	95.4	95.6	95.8	96.0	96.3	96.5
Refrigerating capacity ratio	% (relative to 410A)	96.1	95.8	96.8	96.6	96.4	96.2	95.9	95.7
Condensation glide	° C.	1.65	1.63	1.93	1.92	1.92	1.91	1.89	1.88

TABLE 17-continued

Item	Unit	Example 90	Example 91	Example 92	Example 93	Example 94	Example 95	Example 96	Example 97
Discharge pressure	% (relative to 410A)	101.5	100.9	104.5	103.9	103.4	102.9	102.3	101.8
RCL	g/m ³	41.4	40.7	47.8	46.9	46.0	45.1	44.3	43.5

TABLE 18

Item	Unit	Example 98	Example 99	Example 100	Example 101	Example 102	Example 103	Example 104	Example 105
HFO-1132(E)	mass %	54.0	56.0	58.0	60.0	36.0	38.0	42.0	44.0
HFO-1123	mass %	28.0	26.0	24.0	22.0	44.0	42.0	38.0	36.0
R1234yf	mass %	18.0	18.0	18.0	18.0	20.0	20.0	20.0	20.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.7	96.9	97.1	97.3	95.1	95.3	95.7	95.9
Refrigerating capacity ratio	% (relative to 410A)	95.4	95.2	94.9	94.6	96.3	96.1	95.7	95.4
Condensation glide	° C.	1.86	1.83	1.80	1.77	2.14	2.14	2.13	2.12
Discharge pressure	% (relative to 410A)	101.2	100.6	100.0	99.5	104.5	104.0	103.0	102.5
RCL	g/m ³	42.7	42.0	41.3	40.6	50.7	49.7	47.7	46.8

TABLE 19

Item	Unit	Example 106	Example 107	Example 108	Example 109	Example 110	Example 111	Example 112	Example 113
HFO-1132(E)	mass %	46.0	48.0	52.0	54.0	56.0	58.0	34.0	36.0
HFO-1123	mass %	34.0	32.0	28.0	26.0	24.0	22.0	44.0	42.0
R1234yf	mass %	20.0	20.0	20.0	20.0	20.0	20.0	22.0	22.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.1	96.3	96.7	96.9	97.2	97.4	95.1	95.3
Refrigerating capacity ratio	% (relative to 410A)	95.2	95.0	94.5	94.2	94.0	93.7	95.3	95.1
Condensation glide	° C.	2.11	2.09	2.05	2.02	1.99	1.95	2.37	2.36
Discharge pressure	% (relative to 410A)	101.9	101.4	100.3	99.7	99.2	98.6	103.4	103.0
RCL	g/m ³	45.9	45.0	43.4	42.7	41.9	41.2	51.7	50.6

TABLE 20

Item	Unit	Example 114	Example 115	Example 116	Example 117	Example 118	Example 119	Example 120	Example 121
HFO-1132(E)	mass %	38.0	40.0	42.0	44.0	46.0	48.0	50.0	52.0
HFO-1123	mass %	40.0	38.0	36.0	34.0	32.0	30.0	28.0	26.0
R1234yf	mass %	22.0	22.0	22.0	22.0	22.0	22.0	22.0	22.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	95.5	95.7	95.9	96.1	96.4	96.6	96.8	97.0
Refrigerating capacity ratio	% (relative to 410A)	94.9	94.7	94.5	94.3	94.0	93.8	93.6	93.3
Condensation glide	° C.	2.36	2.35	2.33	2.32	2.30	2.27	2.25	2.21
Discharge pressure	% (relative to 410A)	102.5	102.0	101.5	101.0	100.4	99.9	99.4	98.8
RCL	g/m ³	49.6	48.6	47.6	46.7	45.8	45.0	44.1	43.4

TABLE 21

Item	Unit	Example 122	Example 123	Example 124	Example 125	Example 126	Example 127	Example 128	Example 129
HFO-1132(E)	mass %	54.0	56.0	58.0	60.0	32.0	34.0	36.0	38.0
HFO-1123	mass %	24.0	22.0	20.0	18.0	44.0	42.0	40.0	38.0
R1234yf	mass %	22.0	22.0	22.0	22.0	24.0	24.0	24.0	24.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	97.2	97.4	97.6	97.9	95.2	95.4	95.6	95.8
Refrigerating capacity ratio	% (relative to 410A)	93.0	92.8	92.5	92.2	94.3	94.1	93.9	93.7
Condensation glide	° C.	2.18	2.14	2.09	2.04	2.61	2.60	2.59	2.58
Discharge pressure	% (relative to 410A)	98.2	97.7	97.1	96.5	102.4	101.9	101.5	101.0
RCL	g/m ³	42.6	41.9	41.2	40.5	52.7	51.6	50.5	49.5

TABLE 22

Item	Unit	Example 130	Example 131	Example 132	Example 133	Example 134	Example 135	Example 136	Example 137
HFO-1132(E)	mass %	40.0	42.0	44.0	46.0	48.0	50.0	52.0	54.0
HFO-1123	mass %	36.0	34.0	32.0	30.0	28.0	26.0	24.0	22.0
R1234yf	mass %	24.0	24.0	24.0	24.0	24.0	24.0	24.0	24.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.0	96.2	96.4	96.6	96.8	97.0	97.2	97.5
Refrigerating capacity ratio	% (relative to 410A)	93.5	93.3	93.1	92.8	92.6	92.4	92.1	91.8
Condensation glide	° C.	2.56	2.54	2.51	2.49	2.45	2.42	2.38	2.33
Discharge pressure	% (relative to 410A)	100.5	100.0	99.5	98.9	98.4	97.9	97.3	96.8
RCL	g/m ³	48.5	47.5	46.6	45.7	44.9	44.1	43.3	42.5

TABLE 23

Item	Unit	Example 138	Example 139	Example 140	Example 141	Example 142	Example 143	Example 144	Example 145
HFO-1132(E)	mass %	56.0	58.0	60.0	30.0	32.0	34.0	36.0	38.0
HFO-1123	mass %	20.0	18.0	16.0	44.0	42.0	40.0	38.0	36.0
R1234yf	mass %	24.0	24.0	24.0	26.0	26.0	26.0	26.0	26.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	97.7	97.9	98.1	95.3	95.5	95.7	95.9	96.1
Refrigerating capacity ratio	% (relative to 410A)	91.6	91.3	91.0	93.2	93.1	92.9	92.7	92.5
Condensation glide	° C.	2.28	2.22	2.16	2.86	2.85	2.83	2.81	2.79
Discharge pressure	% (relative to 410A)	96.2	95.6	95.1	101.3	100.8	100.4	99.9	99.4
RCL	g/m ³	41.8	41.1	40.4	53.7	52.6	51.5	50.4	49.4

TABLE 24

Item	Unit	Example 146	Example 147	Example 148	Example 149	Example 150	Example 151	Example 152	Example 153
HFO-1132(E)	mass %	40.0	42.0	44.0	46.0	48.0	50.0	52.0	54.0
HFO-1123	mass %	34.0	32.0	30.0	28.0	26.0	24.0	22.0	20.0
R1234yf	mass %	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.3	96.5	96.7	96.9	97.1	97.3	97.5	97.7
Refrigerating capacity ratio	% (relative to 410A)	92.3	92.1	91.9	91.6	91.4	91.2	90.9	90.6
Condensation glide	° C.	2.77	2.74	2.71	2.67	2.63	2.59	2.53	2.48

TABLE 24-continued

Item	Unit	Exam- ple 146	Exam- ple 147	Exam- ple 148	Exam- ple 149	Exam- ple 150	Exam- ple 151	Exam- ple 152	Exam- ple 153
Discharge pressure	% (relative to 410A)	99.0	98.5	97.9	97.4	96.9	96.4	95.8	95.3
RCL	g/m ³	48.4	47.4	46.5	45.7	44.8	44.0	43.2	42.5

TABLE 25

Item	Unit	Exam- ple 154	Exam- ple 155	Exam- ple 156	Exam- ple 157	Exam- ple 158	Exam- ple 159	Exam- ple 160	Exam- ple 161
HFO-1132(E)	mass %	56.0	58.0	60.0	30.0	32.0	34.0	36.0	38.0
HFO-1123	mass %	18.0	16.0	14.0	42.0	40.0	38.0	36.0	34.0
R1234yf	mass %	26.0	26.0	26.0	28.0	28.0	28.0	28.0	28.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	97.9	98.2	98.4	95.6	95.8	96.0	96.2	96.3
Refrigerating capacity ratio	% (relative to 410A)	90.3	90.1	89.8	92.1	91.9	91.7	91.5	91.3
Condensation glide	° C.	2.42	2.35	2.27	3.10	3.09	3.06	3.04	3.01
Discharge pressure	% (relative to 410A)	94.7	94.1	93.6	99.7	99.3	98.8	98.4	97.9
RCL	g/m ³	41.7	41.0	40.3	53.6	52.5	51.4	50.3	49.3

TABLE 26

Item	Unit	Exam- ple 162	Exam- ple 163	Exam- ple 164	Exam- ple 165	Exam- ple 166	Exam- ple 167	Exam- ple 168	Exam- ple 169
HFO-1132(E)	mass %	40.0	42.0	44.0	46.0	48.0	50.0	52.0	54.0
HFO-1123	mass %	32.0	30.0	28.0	26.0	24.0	22.0	20.0	18.0
R1234yf	mass %	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.5	96.7	96.9	97.2	97.4	97.6	97.8	98.0
Refrigerating capacity ratio	% (relative to 410A)	91.1	90.9	90.7	90.4	90.2	89.9	89.7	89.4
Condensation glide	° C.	2.98	2.94	2.90	2.85	2.80	2.75	2.68	2.62
Discharge pressure	% (relative to 410A)	97.4	96.9	96.4	95.9	95.4	94.9	94.3	93.8
RCL	g/m ³	48.3	47.4	46.4	45.6	44.7	43.9	43.1	42.4

TABLE 27

Item	Unit	Exam- ple 170	Exam- ple 171	Exam- ple 172	Exam- ple 173	Exam- ple 174	Exam- ple 175	Exam- ple 176	Exam- ple 177
HFO-1132(E)	mass %	56.0	58.0	60.0	32.0	34.0	36.0	38.0	42.0
HFO-1123	mass %	16.0	14.0	12.0	38.0	36.0	34.0	32.0	28.0
R1234yf	mass %	28.0	28.0	28.0	30.0	30.0	30.0	30.0	30.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	98.2	98.4	98.6	96.1	96.2	96.4	96.6	97.0
Refrigerating capacity ratio	% (relative to 410A)	89.1	88.8	88.5	90.7	90.5	90.3	90.1	89.7
Condensation glide	° C.	2.54	2.46	2.38	3.32	3.30	3.26	3.22	3.14
Discharge pressure	% (relative to 410A)	93.2	92.6	92.1	97.7	97.3	96.8	96.4	95.4
RCL	g/m ³	41.7	41.0	40.3	52.4	51.3	50.2	49.2	47.3

TABLE 28

Item	Unit	Example 178	Example 179	Example 180	Example 181	Example 182	Example 183	Example 184	Example 185
HFO-1132(E)	mass %	44.0	46.0	48.0	50.0	52.0	54.0	56.0	58.0
HFO-1123	mass %	26.0	24.0	22.0	20.0	18.0	16.0	14.0	12.0
R1234yf	mass %	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	97.2	97.4	97.6	97.8	98.0	98.3	98.5	98.7
Refrigerating capacity ratio	% (relative to 410A)	89.4	89.2	89.0	88.7	88.4	88.2	87.9	87.6
Condensation glide	° C.	3.08	3.03	2.97	2.90	2.83	2.75	2.66	2.57
Discharge pressure	% (relative to 410A)	94.9	94.4	93.9	93.3	92.8	92.3	91.7	91.1
RCL	g/m ³	46.4	45.5	44.7	43.9	43.1	42.3	41.6	40.9

TABLE 29

Item	Unit	Example 186	Example 187	Example 188	Example 189	Example 190	Example 191	Example 192	Example 193
HFO-1132(E)	mass %	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0
HFO-1123	mass %	38.0	36.0	34.0	32.0	30.0	28.0	26.0	24.0
R1234yf	mass %	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.2	96.3	96.5	96.7	96.9	97.1	97.3	97.5
Refrigerating capacity ratio	% (relative to 410A)	89.6	89.5	89.3	89.1	88.9	88.7	88.4	88.2
Condensation glide	° C.	3.60	3.56	3.52	3.48	3.43	3.38	3.33	3.26
Discharge pressure	% (relative to 410A)	96.6	96.2	95.7	95.3	94.8	94.3	93.9	93.4
RCL	g/m ³	53.4	52.3	51.2	50.1	49.1	48.1	47.2	46.3

TABLE 30

Item	Unit	Example 194	Example 195	Example 196	Example 197	Example 198	Example 199	Example 200	Example 201
HFO-1132(E)	mass %	46.0	48.0	50.0	52.0	54.0	56.0	58.0	60.0
HFO-1123	mass %	22.0	20.0	18.0	16.0	14.0	12.0	10.0	8.0
R1234yf	mass %	32.0	32.0	32.0	32.0	32.0	32.0	32.0	32.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	97.7	97.9	98.1	98.3	98.5	98.7	98.9	99.2
Refrigerating capacity ratio	% (relative to 410A)	88.0	87.7	87.5	87.2	86.9	86.6	86.3	86.0
Condensation glide	° C.	3.20	3.12	3.04	2.96	2.87	2.77	2.66	2.55
Discharge pressure	% (relative to 410A)	92.8	92.3	91.8	91.3	90.7	90.2	89.6	89.1
RCL	g/m ³	45.4	44.6	43.8	43.0	42.3	41.5	40.8	40.2

TABLE 31

Item	Unit	Example 202	Example 203	Example 204	Example 205	Example 206	Example 207	Example 208	Example 209
HFO-1132(E)	mass %	30.0	32.0	34.0	36.0	38.0	40.0	42.0	44.0
HFO-1123	mass %	36.0	34.0	32.0	30.0	28.0	26.0	24.0	22.0
R1234yf	mass %	34.0	34.0	34.0	34.0	34.0	34.0	34.0	34.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	96.5	96.6	96.8	97.0	97.2	97.4	97.6	97.8
Refrigerating capacity ratio	% (relative to 410A)	88.4	88.2	88.0	87.8	87.6	87.4	87.2	87.0
Condensation glide	° C.	3.84	3.80	3.75	3.70	3.64	3.58	3.51	3.43

TABLE 31-continued

Item	Unit	Exam- ple 202	Exam- ple 203	Exam- ple 204	Exam- ple 205	Exam- ple 206	Exam- ple 207	Exam- ple 208	Exam- ple 209
Discharge pressure	% (relative to 410A)	95.0	94.6	94.2	93.7	93.3	92.8	92.3	91.8
RCL	g/m ³	53.3	52.2	51.1	50.0	49.0	48.0	47.1	46.2

TABLE 32

Item	Unit	Exam- ple 210	Exam- ple 211	Exam- ple 212	Exam- ple 213	Exam- ple 214	Exam- ple 215	Exam- ple 216	Exam- ple 217
HFO-1132(E)	mass %	46.0	48.0	50.0	52.0	54.0	30.0	32.0	34.0
HFO-1123	mass %	20.0	18.0	16.0	14.0	12.0	34.0	32.0	30.0
R1234yf	mass %	34.0	34.0	34.0	34.0	34.0	36.0	36.0	36.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	98.0	98.2	98.4	98.6	98.8	96.8	96.9	97.1
Refrigerating capacity ratio	% (relative to 410A)	86.7	86.5	86.2	85.9	85.6	87.2	87.0	86.8
Condensation glide	° C.	3.36	3.27	3.18	3.08	2.97	4.08	4.03	3.97
Discharge pressure	% (relative to 410A)	91.3	90.8	90.3	89.7	89.2	93.4	93.0	92.6
RCL	g/m ³	45.3	44.5	43.7	42.9	42.2	53.2	52.1	51.0

TABLE 33

Item	Unit	Exam- ple 218	Exam- ple 219	Exam- ple 220	Exam- ple 221	Exam- ple 222	Exam- ple 223	Exam- ple 224	Exam- ple 225
HFO-1132(E)	mass %	36.0	38.0	40.0	42.0	44.0	46.0	30.0	32.0
HFO-1123	mass %	28.0	26.0	24.0	22.0	20.0	18.0	32.0	30.0
R1234yf	mass %	36.0	36.0	36.0	36.0	36.0	36.0	38.0	38.0
GWP	—	2	2	2	2	2	2	2	2
COP ratio	% (relative to 410A)	97.3	97.5	97.7	97.9	98.1	98.3	97.1	97.2
Refrigerating capacity ratio	% (relative to 410A)	86.6	86.4	86.2	85.9	85.7	85.5	85.9	85.7
Condensation glide	° C.	3.91	3.84	3.76	3.68	3.60	3.50	4.32	4.25
Discharge pressure	% (relative to 410A)	92.1	91.7	91.2	90.7	90.3	89.8	91.9	91.4
RCL	g/m ³	49.9	48.9	47.9	47.0	46.1	45.3	53.1	52.0

TABLE 34

Item	Unit	Example 226	Example 227
HFO-1132(E)	mass %	34.0	36.0
HFO-1123	mass %	28.0	26.0
R1234yf	mass %	38.0	38.0
GWP	—	2	2
COP ratio	% (relative to 410A)	97.4	97.6
Refrigerating capacity ratio	% (relative to 410A)	85.6	85.3
Condensation glide	° C.	4.18	4.11
Discharge pressure	% (relative to 410A)	91.0	90.6
RCL	g/m ³	50.9	49.8

[0606] These results indicate that under the condition that the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum is respectively represented by x, y, and z, when coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments AA', A'B, BD, DC', C'C, CO, and OA that connect the following 7 points:

point A (68.6, 0.0, 31.4),
 point A'(30.6, 30.0, 39.4),
 point B (0.0, 58.7, 41.3),
 point D (0.0, 80.4, 19.6),
 point C' (19.5, 70.5, 10.0),
 point C (32.9, 67.1, 0.0), and
 point O (100.0, 0.0, 0.0),
 or on the above line segments (excluding the points on the line segment CO);
 the line segment AA' is represented by coordinates (x, 0.0016x²-0.9473x+57.497, -0.0016x²-0.0527x+42.503),
 the line segment A'B is represented by coordinates (x, 0.0029x²-1.0268x+58.7, -0.0029x²+0.0268x+41.3),
 the line segment DC' is represented by coordinates (x, 0.0082x²-0.6671x+80.4, -0.0082x²-0.3329x+19.6),
 the line segment C'C is represented by coordinates (x, 0.0067x²-0.6034x+79.729, -0.0067x²-0.3966x+20.271),
 and
 the line segments BD, CO, and OA are straight lines,
 the refrigerant has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP of 92.5% or more relative to that of R410A.

[0607] The point on the line segment AA' was determined by obtaining an approximate curve connecting point A, Example 1, and point A' by the least square method.

[0608] The point on the line segment A'B was determined by obtaining an approximate curve connecting point A', Example 3, and point B by the least square method.

[0609] The point on the line segment DC' was determined by obtaining an approximate curve connecting point D, Example 6, and point C' by the least square method.

[0610] The point on the line segment C'C was determined by obtaining an approximate curve connecting point C', Example 4, and point C by the least square method.

[0611] Likewise, the results indicate that when coordinates (x,y,z) are within the range of a figure surrounded by line segments AA', A'B, BF, FT, TE, EO, and OA that connect the following 7 points:

- point A (68.6, 0.0, 31.4),
- point A' (30.6, 30.0, 39.4),
- point B (0.0, 58.7, 41.3),
- point F (0.0, 61.8, 38.2),
- point T (35.8, 44.9, 19.3),
- point E (58.0, 42.0, 0.0) and
- point O (100.0, 0.0, 0.0),

or on the above line segments (excluding the points on the line EO);

the line segment AA' is represented by coordinates (x, $0.0016x^2 - 0.9473x + 57.497$, $-0.0016x^2 - 0.0527x + 42.503$),

the line segment A'B is represented by coordinates (x, $0.0029x^2 - 1.0268x + 58.7$, $-0.0029x^2 + 0.0268x + 41.3$),

the line segment FT is represented by coordinates (x, $0.0078x^2 - 0.7501x + 61.8$, $-0.0078x^2 - 0.2499x + 38.2$), and

the line segment TE is represented by coordinates (x, $0.0067x^2 - 0.7607x + 63.525$, $-0.0067x^2 - 0.2393x + 36.475$), and

the line segments BF, FO, and OA are straight lines,

the refrigerant has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP of 95% or more relative to that of R410A.

[0612] The point on the line segment FT was determined by obtaining an approximate curve connecting three points, i.e., points T, E', and F, by the least square method.

[0613] The point on the line segment TE was determined by obtaining an approximate curve connecting three points, i.e., points E, R, and T, by the least square method.

[0614] The results in Tables 1 to 34 clearly indicate that in a ternary composition diagram of the mixed refrigerant of HFO-1132(E), HFO-1123, and R1234yf in which the sum of these components is 100 mass %, a line segment connecting a point (0.0, 100.0, 0.0) and a point (0.0, 0.0, 100.0) is the base, the point (0.0, 100.0, 0.0) is on the left side, and the point (0.0, 0.0, 100.0) is on the right side, when coordinates (x,y,z) are on or below the line segment LM connecting point L (63.1, 31.9, 5.0) and point M (60.3, 6.2, 33.5), the refrigerant has an RCL of 40 g/m³ or more.

[0615] The results in Tables 1 to 34 clearly indicate that in a ternary composition diagram of the mixed refrigerant of HFO-1132(E), HFO-1123 and R1234yf in which their sum is 100 mass %, a line segment connecting a point (0.0, 100.0, 0.0) and a point (0.0, 0.0, 100.0) is the base, the point (0.0, 100.0, 0.0) is on the left side, and the point (0.0, 0.0, 100.0) is on the right side, when coordinates (x,y,z) are on the line

segment QR connecting point Q (62.8, 29.6, 7.6) and point R (49.8, 42.3, 7.9) or on the left side of the line segment, the refrigerant has a temperature glide of 1° C. or less.

[0616] The results in Tables 1 to 34 clearly indicate that in a ternary composition diagram of the mixed refrigerant of HFO-1132(E), HFO-1123, and R1234yf in which their sum is 100 mass %, a line segment connecting a point (0.0, 100.0, 0.0) and a point (0.0, 0.0, 100.0) is the base, the point (0.0, 100.0, 0.0) is on the left side, and the point (0.0, 0.0, 100.0) is on the right side, when coordinates (x,y,z) are on the line segment ST connecting point S (62.6, 28.3, 9.1) and point T (35.8, 44.9, 19.3) or on the right side of the line segment, the refrigerant has a discharge pressure of 105% or less relative to that of 410A.

[0617] In these compositions, R1234yf contributes to reducing flammability, and suppressing deterioration of polymerization etc. Therefore, the composition preferably contains R1234yf.

[0618] Further, the burning velocity of these mixed refrigerants whose mixed formulations were adjusted to WCF concentrations was measured according to the ANSI/ASHRAE Standard 34-2013. Compositions having a burning velocity of 10 cm/s or less were determined to be classified as "Class 2L (lower flammability)."

[0619] A burning velocity test was performed using the apparatus shown in FIG. 2 in the following manner. In FIG. 2, reference numeral 901 refers to a sample cell, 902 refers to a high-speed camera, 903 refers to a xenon lamp, 904 refers to a collimating lens, 905 refers to a collimating lens, and 906 refers to a ring filter. First, the mixed refrigerants used had a purity of 99.5% or more, and were degassed by repeating a cycle of freezing, pumping, and thawing until no traces of air were observed on the vacuum gauge. The burning velocity was measured by the closed method. The initial temperature was ambient temperature. Ignition was performed by generating an electric spark between the electrodes in the center of a sample cell. The duration of the discharge was 1.0 to 9.9 ms, and the ignition energy was typically about 0.1 to 1.0 J. The spread of the flame was visualized using schlieren photographs. A cylindrical container (inner diameter: 155 mm, length: 198 mm) equipped with two light transmission acrylic windows was used as the sample cell, and a xenon lamp was used as the light source. Schlieren images of the flame were recorded by a high-speed digital video camera at a frame rate of 600 fps and stored on a PC.

[0620] Each WCF concentration was obtained by using the WCF concentration as the initial concentration and performing a leak simulation using NIST Standard Reference Database REFLEAK Version 4.0.

[0621] Tables 35 and 36 show the results.

TABLE 35

	Item	Unit	G	H	I
WCF	HFO-1132(E)	mass %	72.0	72.0	72.0
	HFO-1123	mass %	28.0	9.6	0.0
	R1234yf	mass %	0.0	18.4	28.0
Burning velocity (WCF)		cm/s	10	10	10

TABLE 36

Item	Unit	J	P	L	N	N'	K	
WCF	HFO-1132(E)	mass %	47.1	55.8	63.1	68.6	65.0	61.3
	HFO-1123	mass %	52.9	42.0	31.9	16.3	7.7	5.4
	R1234yf	mass %	0.0	2.2	5.0	15.1	27.3	33.3
Leak condition that results in WCF		Storage/Shipping -40° C., 92% release, liquid phase side	Storage/Shipping -40° C., 90% release, liquid phase side	Storage/Shipping -40° C., 90% release, gas phase side	Storage/Shipping -40° C., 66% release, gas phase side	Storage/Shipping -40° C., 12% release, gas phase side	Storage/Shipping -40° C., 0% release, gas phase side	
WCF	HFO-1132(E)	mass %	72.0	72.0	72.0	72.0	72.0	72.0
	HFO-1123	mass %	28.0	17.8	17.4	13.6	12.3	9.8
	R1234yf	mass %	0.0	10.2	10.6	14.4	15.7	18.2
Burning velocity (WCF)		cm/s	8 or less	8 or less	8 or less	9	9	8 or less
Burning velocity (WCF)		cm/s	10	10	10	10	10	10

[0622] The results in Table 35 clearly indicate that when a mixed refrigerant of HFO-1132(E), HFO-1123, and R1234yf contains HFO-1132(E) in a proportion of 72.0 mass % or less based on their sum, the refrigerant can be determined to have a WCF lower flammability.

[0623] The results in Tables 36 clearly indicate that in a ternary composition diagram of a mixed refrigerant of HFO-1132(E), HFO-1123, and R1234yf in which their sum is 100 mass %, and a line segment connecting a point (0.0, 100.0, 0.0) and a point (0.0, 0.0, 100.0) is the base, when coordinates (x,y,z) are on or below the line segments JP, PN, and NK connecting the following 6 points:

point J (47.1, 52.9, 0.0),

point P (55.8, 42.0, 2.2),

point L (63.1, 31.9, 5.0)

point N (68.6, 16.3, 15.1)

point N' (65.0, 7.7, 27.3) and

point K (61.3, 5.4, 33.3),

the refrigerant can be determined to have a WCF lower flammability, and a WCF lower flammability.

In the diagram, the line segment PN is represented by coordinates (x, $-0.1135x^2+12.112x-280.43$, $0.1135x^2-13.112x+380.43$),

and the line segment NK is represented by coordinates (x, $0.2421x^2-29.955x+931.91$, $-0.2421x^2+28.955x-831.91$).

[0624] The point on the line segment PN was determined by obtaining an approximate curve connecting three points, i.e., points P, L, and N, by the least square method.

[0625] The point on the line segment NK was determined by obtaining an approximate curve connecting three points, i.e., points N, N', and K, by the least square method.

(5-2) Refrigerant B

[0626] The refrigerant B according to the present disclosure is

[0627] a mixed refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)) and trifluoroethylene (HFO-1123) in a total amount of 99.5 mass % or more based on the entire refrigerant, and the refrigerant comprising 62.0 mass % to 72.0 mass % or 45.1 mass % to 47.1 mass % of HFO-1132 (E) based on the entire refrigerant, or

[0628] a mixed refrigerant comprising HFO-1132(E) and HFO-1123 in a total amount of 99.5 mass % or more based

on the entire refrigerant, and the refrigerant comprising 45.1 mass % to 47.1 mass % of HFO-1132(E) based on the entire refrigerant.

[0629] The refrigerant B according to the present disclosure has various properties that are desirable as an R410A-alternative refrigerant, i.e., (1) a coefficient of performance equivalent to that of R410A, (2) a refrigerating capacity equivalent to that of R410A, (3) a sufficiently low GWP, and (4) a lower flammability (Class 2L) according to the ASHRAE standard.

[0630] When the refrigerant B according to the present disclosure is a mixed refrigerant comprising 72.0 mass % or less of HFO-1132(E), it has WCF lower flammability. When the refrigerant B according to the present disclosure is a composition comprising 47.1% or less of HFO-1132(E), it has WCF lower flammability and WCF lower flammability, and is determined to be "Class 2L," which is a lower flammable refrigerant according to the ASHRAE standard, and which is further easier to handle.

[0631] When the refrigerant B according to the present disclosure comprises 62.0 mass % or more of HFO-1132(E), it becomes superior with a coefficient of performance of 95% or more relative to that of R410A, the polymerization reaction of HFO-1132(E) and/or HFO-1123 is further suppressed, and the stability is further improved. When the refrigerant B according to the present disclosure comprises 45.1 mass % or more of HFO-1132(E), it becomes superior with a coefficient of performance of 93% or more relative to that of R410A, the polymerization reaction of HFO-1132(E) and/or HFO-1123 is further suppressed, and the stability is further improved.

[0632] The refrigerant B according to the present disclosure may further comprise other additional refrigerants in addition to HFO-1132(E) and HFO-1123, as long as the above properties and effects are not impaired. In this respect, the refrigerant according to the present disclosure preferably comprises HFO-1132(E) and HFO-1123 in a total amount of 99.75 mass % or more, and more preferably 99.9 mass % or more, based on the entire refrigerant.

[0633] Such additional refrigerants are not limited, and can be selected from a wide range of refrigerants. The mixed refrigerant may comprise a single additional refrigerant, or two or more additional refrigerants.

(Examples of Refrigerant B)

[0634] The present disclosure is described in more detail below with reference to Examples of refrigerant B. However, the refrigerant B is not limited to the Examples.

[0635] Mixed refrigerants were prepared by mixing HFO-1132(E) and HFO-1123 at mass % based on their sum shown in Tables 37 and 38.

[0636] The GWP of compositions each comprising a mixture of R410A (R32=50%/R125=50%) was evaluated based on the values stated in the Intergovernmental Panel on Climate Change (IPCC), fourth report. The GWP of HFO-1132(E), which was not stated therein, was assumed to be 1 from HFO-1132a (GWP=1 or less) and HFO-1123 (GWP=0.3, described in Patent Literature 1). The refrigerating capacity of compositions each comprising R410A and a mixture of HFO-1132(E) and HFO-1123 was determined by performing theoretical refrigeration cycle calculations for the mixed refrigerants using the National Institute of Science and Technology (NIST) and Reference Fluid Thermodynamic and Transport Properties Database (Refprop 9.0) under the following conditions.

Evaporating temperature: 5° C.

Condensation temperature: 45° C.

Superheating temperature: 5 K

Subcooling temperature: 5 K

Compressor efficiency: 70%

[0637] The composition of each mixture was defined as WCF. A leak simulation was performed using NIST Standard Reference Data Base Refleak Version 4.0 under the conditions of Equipment, Storage, Shipping, Leak, and Recharge according to the ASHRAE Standard 34-2013. The most flammable fraction was defined as WCFE.

[0638] Tables 1 and 2 show GWP, COP, and refrigerating capacity, which were calculated based on these results. The COP and refrigerating capacity are ratios relative to R410A.

[0639] The coefficient of performance (COP) was determined by the following formula.

$$\text{COP} = \frac{\text{refrigerating capacity or heating capacity}}{\text{power consumption}}$$

[0640] For the flammability, the burning velocity was measured according to the ANSI/ASHRAE Standard 34-2013. Both WCF and WCFE having a burning velocity of 10 cm/s or less were determined to be “Class 2L (lower flammability).”

[0641] A burning velocity test was performed using the apparatus shown in FIG. 1 in the following manner. First, the mixed refrigerants used had a purity of 99.5% or more, and were degassed by repeating a cycle of freezing, pumping, and thawing until no traces of air were observed on the vacuum gauge. The burning velocity was measured by the closed method. The initial temperature was ambient temperature. Ignition was performed by generating an electric spark between the electrodes in the center of a sample cell. The duration of the discharge was 1.0 to 9.9 ms, and the ignition energy was typically about 0.1 to 1.0 J. The spread of the flame was visualized using schlieren photographs. A cylindrical container (inner diameter: 155 mm, length: 198 mm) equipped with two light transmission acrylic windows was used as the sample cell, and a xenon lamp was used as the light source. Schlieren images of the flame were recorded by a high-speed digital video camera at a frame rate of 600 fps and stored on a PC.

TABLE 37

Item	Unit	Comparative Example 1 R410A	Comparative Example 2 HFO-1132E	Comparative Example 3	Example 1	Example 2	Example 3	Example 4	Example 5	Comparative Example 4
HFO-1132E (WCF)	mass %	—	100	80	72	70	68	65	62	60
HFO-1123 (WCF)	mass %		0	20	28	30	32	35	38	40
GWP	—	2088	1	1	1	1	1	1	1	1
COP ratio	% (relative to R410A)	100	99.7	97.5	96.6	96.3	96.1	95.8	95.4	95.2
Refrigerating capacity ratio	% (relative to R410A)	100	98.3	101.9	103.1	103.4	103.8	104.1	104.5	104.8
Discharge pressure	Mpa	2.73	2.71	2.89	2.96	2.98	3.00	3.02	3.04	3.06
Burning velocity (WCF)	cm/sec	Non-flammable	20	13	10	9	9	8	8 or less	8 or less

TABLE 38

Item	Unit	Comparative Example 5	Comparative Example 6	Example 7	Example 8	Example 9
HFO-1132E (WCF)	mass %	50	48	47.1	46.1	45.1
HFO-1123 (WCF)	mass %	50	52	52.9	53.9	54.9
GWP	—	1	1	1	1	1
COP ratio	% (relative to R410A)	94.1	93.9	93.8	93.7	93.6
Refrigerating capacity ratio	% (relative to R410A)	105.9	106.1	106.2	106.3	106.4

TABLE 38-continued

Discharge pressure	Mpa	3.14	3.16	3.16	3.17	3.18
Leakage test conditions (WCFF)		Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side
HFO-1132E (WCFF)	mass %	74	73	72	71	70
HFO-1123 (WCFF)	mass %	26	27	28	29	30
Burning velocity (WCF)	cm/sec	8 or less	8 or less	8 or less	8 or less	8 or less
Burning velocity (WCFF)	cm/sec	11	10.5	10.0	9.5	9.5
ASHRAE flammability classification		2	2	2L	2L	2L

Item	Unit	Comparative Example 7	Comparative Example 8	Comparative Example 9	Comparative Example 10 HFO-1123
HFO-1132E (WCF)	mass %	43	40	25	0
HFO-1123 (WCF)	mass %	57	60	75	100
GWP	—	1	1	1	1
COP ratio	% (relative to R410A)	93.4	93.1	91.9	90.6
Refrigerating capacity ratio	% (relative to R410A)	106.6	106.9	107.9	108.0
Discharge pressure	Mpa	3.20	3.21	3.31	3.39
Leakage test conditions (WCFF)		Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 90% release, liquid phase side	—
HFO-1132E (WCFF)	mass %	67	63	38	—
HFO-1123 (WCFF)	mass %	33	37	62	—
Burning velocity (WCF)	cm/sec	8 or less	8 or less	8 or less	5
Burning velocity (WCFF)	cm/sec	8.5	8 or less	8 or less	—
ASHRAE flammability classification		2L	2L	2L	2L

[0642] The compositions each comprising 62.0 mass % to 72.0 mass % of HFO-1132(E) based on the entire composition are stable while having a low GWP (GWP=1), and they ensure WCF lower flammability. Further, surprisingly, they can ensure performance equivalent to that of R410A. Moreover, compositions each comprising 45.1 mass % to 47.1 mass % of HFO-1132(E) based on the entire composition are stable while having a low GWP (GWP=1), and they ensure WCFF lower flammability. Further, surprisingly, they can ensure performance equivalent to that of R410A.

(5-3) Refrigerant C

[0643] The refrigerant C according to the present disclosure is a composition comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), 2,3,3,3-tetrafluoro-1-propene (R1234yf), and difluoromethane (R32),

and satisfies the following requirements. The refrigerant C according to the present disclosure has various properties that are desirable as an alternative refrigerant for R410A; i.e. it has a coefficient of performance and a refrigerating capacity that are equivalent to those of R410A, and a sufficiently low GWP.

Requirements

[0644] Preferable refrigerant C is as follows:

[0645] When the mass % of HFO-1132(E), HFO-1123, R1234yf, and R32 based on their sum is respectively represented by x, y, z, and a,

[0646] if $0 < a \leq 11.1$, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is (100-a) mass % are within the range

of a figure surrounded by straight lines GI, IA, AB, BD', D' C, and CG that connect the following 6 points:

point G (0.026a²-1.7478a+72.0, -0.026a²+0.7478a+28.0, 0.0),

point I (0.026a²-1.7478a+72.0, 0.0, -0.026a²+0.7478a+28.0),

point A (0.0134a²-1.9681a+68.6, 0.0, -0.0134a²+0.9681a+31.4),

point B (0.0, 0.0144a²-1.6377a+58.7, -0.0144a²+0.6377a+41.3),

point D' (0.0, 0.0224a²+0.968a+75.4, -0.0224a²-1.968a+24.6), and

point C (-0.2304a²-0.4062a+32.9, 0.2304a²-0.5938a+67.1, 0.0),

or on the straight lines GI, AB, and D'C (excluding point G, point I, point A, point B, point D', and point C);

[0647] if 11.1<a≤18.2, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines GI, IA, AB, BW, and WG that connect the following 5 points:

point G (0.02a²-1.6013a+71.105, -0.02a²+0.6013a+28.895, 0.0),

point I (0.02a²-1.6013a+71.105, 0.0, -0.02a²+0.6013a+28.895),

point A (0.0112a²-1.9337a+68.484, 0.0, -0.0112a²+0.9337a+31.516),

point B (0.0, 0.0075a²-1.5156a+58.199, -0.0075a²+0.5156a+41.801) and

point W (0.0, 100.0-a, 0.0),

or on the straight lines GI and AB (excluding point G, point I, point A, point B, and point W);

[0648] if 18.2<a≤26.7, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines GI, IA, AB, BW, and WG that connect the following 5 points:

point G (0.0135a²-1.4068a+69.727, -0.0135a²+0.4068a+30.273, 0.0),

point I (0.0135a²-1.4068a+69.727, 0.0, -0.0135a²+0.4068a+30.273),

point A (0.0107a²-1.9142a+68.305, 0.0, -0.0107a²+0.9142a+31.695),

point B (0.0, 0.009a²-1.6045a+59.318, -0.009a²+0.6045a+40.682) and

point W (0.0, 100.0-a, 0.0),

or on the straight lines GI and AB (excluding point G, point I, point A, point B, and point W);

[0649] if 26.7<a≤36.7, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines GI, IA, AB, BW, and WG that connect the following 5 points:

point G (0.0111a²-1.3152a+68.986, -0.0111a²+0.3152a+31.014, 0.0),

point I (0.0111a²-1.3152a+68.986, 0.0, -0.0111a²+0.3152a+31.014),

point A (0.0103a²-1.9225a+68.793, 0.0, -0.0103a²+0.9225a+31.207),

point B (0.0, 0.0046a²-1.41a+57.286, -0.0046a²+0.41a+42.714) and

point W (0.0, 100.0-a, 0.0),

or on the straight lines GI and AB (excluding point G, point I, point A, point B, and point W); and

[0650] if 36.7<a≤46.7, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure sur-

rounded by straight lines GI, IA, AB, BW, and WG that connect the following 5 points:

point G (0.0061a²-0.9918a+63.902, -0.0061a²-0.0082a+36.098, 0.0),

point I (0.0061a²-0.9918a+63.902, 0.0, -0.0061a²-0.0082a+36.098),

point A (0.0085a²-1.8102a+67.1, 0.0, -0.0085a²+0.8102a+32.9),

point B (0.0, 0.0012a²-1.1659a+52.95, -0.0012a²+0.1659a+47.05) and

point W (0.0, 100.0-a, 0.0),

or on the straight lines GI and AB (excluding point G, point I, point A, point B, and point W). When the refrigerant according to the present disclosure satisfies the above requirements, it has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP ratio of 92.5% or more relative to that of R410A, and further ensures a WCF lower flammability.

[0651] The refrigerant C according to the present disclosure is preferably a refrigerant wherein

[0652] when the mass % of HFO-1132(E), HFO-1123, and R1234yf based on their sum is respectively represented by x, y, and z,

[0653] if 0<a≤11.1, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is (100-a) mass % are within the range of a figure surrounded by straight lines JK', K'B, BD', D'C, and CJ that connect the following 5 points:

point J (0.0049a²-0.9645a+47.1, -0.0049a²-0.0355a+52.9, 0.0),

point K' (0.0514a²-2.4353a+61.7, -0.0323a²+0.4122a+5.9, -0.0191a²+1.0231a+32.4),

point B (0.0, 0.0144a²-1.6377a+58.7, -0.0144a²+0.6377a+41.3),

point D' (0.0, 0.0224a²+0.968a+75.4, -0.0224a²-1.968a+24.6), and

point C (-0.2304a²-0.4062a+32.9, 0.2304a²-0.5938a+67.1, 0.0),

or on the straight lines JK', K'B, and D'C (excluding point J, point B, point D', and point C);

[0654] if 11.1<a≤18.2, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines JK', K'B, BW, and WJ that connect the following 4 points:

point J (0.0243a²-1.4161a+49.725, -0.0243a²+0.4161a+50.275, 0.0),

point K' (0.0341a²-2.1977a+61.187, -0.0236a²+0.34a+5.636, -0.0105a²+0.8577a+33.177),

point B (0.0, 0.0075a²-1.5156a+58.199, -0.0075a²+0.5156a+41.801) and

point W (0.0, 100.0-a, 0.0),

or on the straight lines JK' and K'B (excluding point J, point B, and point W);

[0655] if 18.2<a≤26.7, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines JK', K'B, BW, and WJ that connect the following 4 points:

point J (0.0246a²-1.4476a+50.184, -0.0246a²+0.4476a+49.816, 0.0),

point K' (0.0196a²-1.7863a+58.515, -0.0079a²-0.1136a+8.702, -0.0117a²+0.8999a+32.783),

point B (0.0, 0.009a²-1.6045a+59.318, -0.009a²+0.6045a+40.682) and

point W (0.0, 100.0-a, 0.0),

or on the straight lines JK' and K'B (excluding point J, point B, and point W);

[0656] if $26.7 < a \leq 36.7$, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines JK', K'A, AB, BW, and WJ that connect the following 5 points:

point J ($0.0183a^2 - 1.1399a + 46.493$, $-0.0183a^2 + 0.1399a + 53.507$, 0.0),

point K' ($-0.0051a^2 + 0.0929a + 25.95$, 0.0, $0.0051a^2 - 1.0929a + 74.05$),

point A ($0.0103a^2 - 1.9225a + 68.793$, 0.0, $-0.0103a^2 + 0.9225a + 31.207$),

point B (0.0, $0.0046a^2 - 1.41a + 57.286$, $-0.0046a^2 + 0.41a + 42.714$) and

point W (0.0, $100.0 - a$, 0.0),

or on the straight lines JK', K'A, and AB (excluding point J, point B, and point W); and

[0657] if $36.7 < a \leq 46.7$, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines JK', K'A, AB, BW, and WJ that connect the following 5 points:

point J ($-0.0134a^2 + 1.0956a + 7.13$, $0.0134a^2 - 2.0956a + 92.87$, 0.0),

point K' ($-1.892a + 29.443$, 0.0, $0.892a + 70.557$),

point A ($0.0085a^2 - 1.8102a + 67.1$, 0.0, $-0.0085a^2 + 0.8102a + 32.9$),

point B (0.0, $0.0012a^2 - 1.1659a + 52.95$, $-0.0012a^2 + 0.1659a + 47.05$) and

point W (0.0, $100.0 - a$, 0.0),

or on the straight lines JK', K'A, and AB (excluding point J, point B, and point W). When the refrigerant according to the present disclosure satisfies the above requirements, it has a refrigerating capacity ratio of 85% or more relative to that of R410A, and a COP ratio of 92.5% or more relative to that of R410A. Additionally, the refrigerant has a WCF lower flammability and a WCF lower flammability, and is classified as "Class 2L," which is a lower flammable refrigerant according to the ASHRAE standard.

[0658] When the refrigerant C according to the present disclosure further contains R32 in addition to HFO-1132(E), HFO-1123, and R1234yf, the refrigerant may be a refrigerant wherein when the mass % of HFO-1132(E), HFO-1123, R1234yf, and R32 based on their sum is respectively represented by x, y, z, and a,

[0659] if $0 < a \leq 10.0$, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is (100-a) mass % are within the range of a figure surrounded by straight lines that connect the following 4 points:

point a ($0.02a^2 - 2.46a + 93.4$, 0, $-0.02a^2 + 2.46a + 6.6$),

point b' ($-0.008a^2 - 1.38a + 56$, $0.018a^2 - 0.53a + 26.3$, $-0.01a^2 + 1.91a + 17.7$),

point c ($-0.016a^2 + 1.02a + 77.6$, $0.016a^2 - 1.02a + 22.4$, 0), and

point o ($100.0 - a$, 0.0, 0.0)

or on the straight lines oa, ab', and b'c (excluding point o and point c);

[0660] if $10.0 < a \leq 16.5$, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines that connect the following 4 points:

point a ($0.0244a^2 - 2.5695a + 94.056$, 0, $-0.0244a^2 + 2.5695a + 5.944$),

point b' ($0.1161a^2 - 1.9959a + 59.749$, $0.014a^2 - 0.3399a + 24.8$, $-0.1301a^2 + 2.3358a + 15.451$),

point c ($-0.0161a^2 + 1.02a + 77.6$, $0.0161a^2 - 1.02a + 22.4$, 0), and

point o ($100.0 - a$, 0.0, 0.0),

or on the straight lines oa, ab', and b'c (excluding point o and point c); or

[0661] if $16.5 < a \leq 21.8$, coordinates (x,y,z) in the ternary composition diagram are within the range of a figure surrounded by straight lines that connect the following 4 points:

point a ($0.0161a^2 - 2.3535a + 92.742$, 0, $-0.0161a^2 + 2.3535a + 7.258$),

point b' ($-0.0435a^2 - 0.0435a + 50.406$, $0.0304a^2 + 1.8991a - 0.0661$, $0.0739a^2 - 1.8556a + 49.6601$),

point c ($-0.0161a^2 + 0.9959a + 77.851$, $0.0161a^2 - 0.9959a + 22.149$, 0), and

point o ($100.0 - a$, 0.0, 0.0),

or on the straight lines oa, ab', and b'c (excluding point o and point c). Note that when point b in the ternary composition diagram is defined as a point where a refrigerating capacity ratio of 95% relative to that of R410A and a COP ratio of 95% relative to that of R410A are both achieved, point b' is the intersection of straight line ab and an approximate line formed by connecting the points where the COP ratio relative to that of R410A is 95%. When the refrigerant according to the present disclosure meets the above requirements, the refrigerant has a refrigerating capacity ratio of 95% or more relative to that of R410A, and a COP ratio of 95% or more relative to that of R410A.

[0662] The refrigerant C according to the present disclosure may further comprise other additional refrigerants in addition to HFO-1132(E), HFO-1123, R1234yf, and R32 as long as the above properties and effects are not impaired. In this respect, the refrigerant according to the present disclosure preferably comprises HFO-1132(E), HFO-1123, R1234yf, and R32 in a total amount of 99.5 mass % or more, more preferably 99.75 mass % or more, and still more preferably 99.9 mass % or more, based on the entire refrigerant.

[0663] The refrigerant C according to the present disclosure may comprise HFO-1132(E), HFO-1123, R1234yf, and R32 in a total amount of 99.5 mass % or more, 99.75 mass % or more, or 99.9 mass % or more, based on the entire refrigerant.

[0664] Additional refrigerants are not particularly limited and can be widely selected. The mixed refrigerant may contain one additional refrigerant, or two or more additional refrigerants.

(Examples of Refrigerant C)

[0665] The present disclosure is described in more detail below with reference to Examples of refrigerant C. However, the refrigerant C is not limited to the Examples.

[0666] Mixed refrigerants were prepared by mixing HFO-1132(E), HFO-1123, R1234yf, and R32 at mass % based on their sum shown in Tables 39 to 96.

[0667] The GWP of compositions each comprising a mixture of R410A (R32=50%/R125=50%) was evaluated based on the values stated in the Intergovernmental Panel on Climate Change (IPCC), fourth report. The GWP of HFO-1132(E), which was not stated therein, was assumed to be 1 from HFO-1132a (GWP=1 or less) and HFO-1123 (GWP=0.3, described in Patent Literature 1). The refrigerating capacity of compositions each comprising R410A and a mixture of HFO-1132(E) and HFO-1123 was determined by performing theoretical refrigeration cycle calculations for the

mixed refrigerants using the National Institute of Science and Technology (NIST) and Reference Fluid Thermodynamic and Transport Properties Database (Refprop 9.0) under the following conditions.

[0668] For each of these mixed refrigerants, the COP ratio and the refrigerating capacity ratio relative to those of R410 were obtained. Calculation was conducted under the following conditions.

[0669] Evaporating temperature: 5° C.

[0670] Condensation temperature: 45° C.

[0671] Superheating temperature: 5 K

[0672] Subcooling temperature: 5 K

[0673] Compressor efficiency: 70%

[0674] Tables 39 to 96 show the resulting values together with the GWP of each mixed refrigerant. The COP and refrigerating capacity are ratios relative to R410A.

[0675] The coefficient of performance (COP) was determined by the following formula.

$$\text{COP} = \frac{\text{refrigerating capacity or heating capacity}}{\text{power consumption}}$$

TABLE 39

Item	Unit	Comp. Ex. 1	Comp. Ex. 2 A	Comp. Ex. 3 B	Comp. Ex. 4 C	Comp. Ex. 5 D'	Comp. Ex. 6 G	Comp. Ex. 7 I	Comp. Ex. 8 J	Comp. Ex. 1 K'
HFO-1132(E)	Mass %	R410A	68.6	0.0	32.9	0.0	72.0	72.0	47.1	61.7
HFO-1123	Mass %		0.0	58.7	67.1	75.4	28.0	0.0	52.9	5.9
R1234yf	Mass %		31.4	41.3	0.0	24.6	0.0	28.0	0.0	32.4
R32	Mass %		0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
GWP	—	2088	2	2	1	2	1	2	1	2
COP ratio	% (relative to R410A)	100	100.0	95.5	92.5	93.1	96.6	99.9	93.8	99.4
Refrigerating capacity ratio	% (relative to R410A)	100	85.0	85.0	107.4	95.0	103.1	86.6	106.2	85.5

TABLE 40

Item	Unit	Comp. Ex. 9 A	Comp. Ex. 10 B	Comp. Ex. 11 C	Comp. Ex. 12 D'	Comp. Ex. 13 G	Comp. Ex. 14 I	Comp. Ex. 15 J	Comp. Ex. 16 K'
HFO-1132(E)	Mass %	55.3	0.0	18.4	0.0	60.9	60.9	40.5	47.0
HFO-1123	Mass %	0.0	47.8	74.5	83.4	32.0	0.0	52.4	7.2
R1234yf	Mass %	37.6	45.1	0.0	9.5	0.0	32.0	0.0	38.7
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	50	50	49	49	49	50	49	50
COP ratio	% (relative to R410A)	99.8	96.9	92.5	92.5	95.9	99.6	94.0	99.2
Refrigerating capacity ratio	% (relative to R410A)	85.0	85.0	110.5	106.0	106.5	87.7	108.9	85.5

TABLE 41

Item	Unit	Comp. Ex. 16 A	Comp. Ex. 17 B	Comp. Ex. 18 C = D'	Comp. Ex. 19 G	Comp. Ex. 20 I	Comp. Ex. 21 J	Comp. Ex. 22 K'
HFO-1132(E)	Mass %	48.4	0.0	0.0	55.8	55.8	37.0	41.0
HFO-1123	Mass %	0.0	42.3	88.9	33.1	0.0	51.9	6.5
R1234yf	Mass %	40.5	46.6	0.0	0.0	33.1	0.0	41.4
R32	Mass %	11.1	11.1	11.1	11.1	11.1	11.1	11.1
GWP	—	77	77	76	76	77	76	77
COP ratio	% (relative to R410A)	99.8	97.6	92.5	95.8	99.5	94.2	99.3
Refrigerating capacity ratio	% (relative to R410A)	85.0	85.0	112.0	108.0	88.6	110.2	85.4

TABLE 42

Item	Unit	Comp. Ex. 22 A	Comp. Ex. 23 B	Comp. Ex. 24 G	Comp. Ex. 25 I	Comp. Ex. 26 J	Comp. Ex. 27 K'
HFO-1132(E)	Mass %	42.8	0.0	52.1	52.1	34.3	36.5
HFO-1123	Mass %	0.0	37.8	33.4	0.0	51.2	5.6
R1234yf	Mass %	42.7	47.7	0.0	33.4	0.0	43.4
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	100	100	99	100	99	100

TABLE 42-continued

Item	Unit	Comp. Ex. 22 A	Comp. Ex. 23 B	Comp. Ex. 24 G	Comp. Ex. 25 I	Comp. Ex. 26 J	Comp. Ex. 4 K'
COP ratio	% (relative to R410A)	99.9	98.1	95.8	99.5	94.4	99.5
Refrigerating capacity ratio	% (relative to R410A)	85.0	85.0	109.1	89.6	111.1	85.3

TABLE 43

Item	Unit	Comp. Ex. 27 A	Comp. Ex. 28 B	Comp. Ex. 29 G	Comp. Ex. 30 I	Comp. Ex. 31 J	Comp. Ex. 5 K'
HFO-1132(E)	Mass %	37.0	0.0	48.6	48.6	32.0	32.5
HFO-1123	Mass %	0.0	33.1	33.2	0.0	49.8	4.0
R1234yf	Mass %	44.8	48.7	0.0	33.2	0.0	45.3
R32	Mass %	18.2	18.2	18.2	18.2	18.2	18.2
GWP	—	125	125	124	125	124	125
COP ratio	% (relative to R410A)	100.0	98.6	95.9	99.4	94.7	99.8
Refrigerating capacity ratio	% (relative to R410A)	85.0	85.0	110.1	90.8	111.9	85.2

TABLE 44

Item	Unit	Comp. Ex. 32 A	Comp. Ex. 33 B	Comp. Ex. 34 G	Comp. Ex. 35 I	Comp. Ex. 36 J	Comp. Ex. 6 K'
HFO-1132(E)	Mass %	31.5	0.0	45.4	45.4	30.3	28.8
HFO-1123	Mass %	0.0	28.5	32.7	0.0	47.8	2.4
R1234yf	Mass %	46.6	49.6	0.0	32.7	0.0	46.9
R32	Mass %	21.9	21.9	21.9	21.9	21.9	21.9
GWP	—	150	150	149	150	149	150
COP ratio	% (relative to R410A)	100.2	99.1	96.0	99.4	95.1	100.0
Refrigerating capacity ratio	% (relative to R410A)	85.0	85.0	111.0	92.1	112.6	85.1

TABLE 45

Item	Unit	Comp. Ex. 37 A	Comp. Ex. 38 B	Comp. Ex. 39 G	Comp. Ex. 40 I	Comp. Ex. 41 J	Comp. Ex. 42 K'
HFO-1132(E)	Mass %	24.8	0.0	41.8	41.8	29.1	24.8
HFO-1123	Mass %	0.0	22.9	31.5	0.0	44.2	0.0
R1234yf	Mass %	48.5	50.4	0.0	31.5	0.0	48.5
R32	Mass %	26.7	26.7	26.7	26.7	26.7	26.7
GWP	—	182	182	181	182	181	182
COP ratio	% (relative to R410A)	100.4	99.8	96.3	99.4	95.6	100.4
Refrigerating capacity ratio	% (relative to R410A)	85.0	85.0	111.9	93.8	113.2	85.0

TABLE 46

Item	Unit	Comp. Ex. 43 A	Comp. Ex. 44 B	Comp. Ex. 45 G	Comp. Ex. 46 I	Comp. Ex. 47 J	Comp. Ex. 48 K'
HFO-1132(E)	Mass %	21.3	0.0	40.0	40.0	28.8	24.3
HFO-1123	Mass %	0.0	19.9	30.7	0.0	41.9	0.0
R1234yf	Mass %	49.4	50.8	0.0	30.7	0.0	46.4
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	200	200	198	199	198	200

TABLE 50-continued

Item	Unit	Comp.							
		Ex. 66	Ex. 7	Ex. 8	Ex. 9	Ex. 10	Ex. 11	Ex. 12	Ex. 13
COP ratio	% (relative to R410A)	92.4	92.6	92.8	93.1	93.4	93.7	94.1	94.5
Refrigerating capacity ratio	% (relative to R410A)	108.4	108.3	108.2	107.9	107.6	107.2	106.8	106.3

TABLE 51

Item	Unit	Ex. 14	Ex. 15	Ex. 16	Ex. 17	Comp.			
						Ex. 67	Ex. 18	Ex. 19	Ex. 20
HFO-1132(E)	Mass %	45.0	50.0	55.0	60.0	65.0	10.0	15.0	20.0
HFO-1123	Mass %	42.9	37.9	32.9	27.9	22.9	72.9	67.9	62.9
R1234yf	Mass %	5.0	5.0	5.0	5.0	5.0	10.0	10.0	10.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	49	49	49	49	49	49	49	49
COP ratio	% (relative to R410A)	95.0	95.4	95.9	96.4	96.9	93.0	93.3	93.6
Refrigerating capacity ratio	% (relative to R410A)	105.8	105.2	104.5	103.9	103.1	105.7	105.5	105.2

TABLE 52

Item	Unit	Ex. 21	Ex. 22	Ex. 23	Ex. 24	Ex. 25	Ex. 26	Ex. 27	Ex. 28
HFO-1123	Mass %	57.9	52.9	47.9	42.9	37.9	32.9	27.9	22.9
R1234yf	Mass %	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	49	49	49	49	49	49	49	49
COP ratio	% (relative to R410A)	93.9	94.2	94.6	95.0	95.5	96.0	96.4	96.9
Refrigerating capacity ratio	% (relative to R410A)	104.9	104.5	104.1	103.6	103.0	102.4	101.7	101.0

TABLE 53

Item	Unit	Comp.							
		Ex. 68	Ex. 29	Ex. 30	Ex. 31	Ex. 32	Ex. 33	Ex. 34	Ex. 35
HFO-1132(E)	Mass %	65.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
HFO-1123	Mass %	17.9	67.9	62.9	57.9	52.9	47.9	42.9	37.9
R1234yf	Mass %	10.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	49	49	49	49	49	49	49	49
COP ratio	% (relative to R410A)	97.4	93.5	93.8	94.1	94.4	94.8	95.2	95.6
Refrigerating capacity ratio	% (relative to R410A)	100.3	102.9	102.7	102.5	102.1	101.7	101.2	100.7

TABLE 54

Item	Unit	Ex. 36	Ex. 37	Ex. 38	Ex. 39	Comp.			
						Ex. 69	Ex. 40	Ex. 41	Ex. 42
HFO-1132(E)	Mass %	45.0	50.0	55.0	60.0	65.0	10.0	15.0	20.0
HFO-1123	Mass %	32.9	27.9	22.9	17.9	12.9	62.9	57.9	52.9
R1234yf	Mass %	15.0	15.0	15.0	15.0	15.0	20.0	20.0	20.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	49	49	49	49	49	49	49	49
COP ratio	% (relative to R410A)	96.0	96.5	97.0	97.5	98.0	94.0	94.3	94.6
Refrigerating capacity ratio	% (relative to R410A)	100.1	99.5	98.9	98.1	97.4	100.1	99.9	99.6

TABLE 55

Item	Unit	Ex. 43	Ex. 44	Ex. 45	Ex. 46	Ex. 47	Ex. 48	Ex. 49	Ex. 50
HFO-1132(E)	Mass %	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0
HFO-1123	Mass %	47.9	42.9	37.9	32.9	27.9	22.9	17.9	12.9
R1234yf	Mass %	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	49	49	49	49	49	49	49	49
COP ratio	% (relative to R410A)	95.0	95.3	95.7	96.2	96.6	97.1	97.6	98.1
Refrigerating capacity ratio	% (relative to R410A)	99.2	98.8	98.3	97.8	97.2	96.6	95.9	95.2

TABLE 56

Item	Unit	Comp. Ex. 70	Ex. 51	Ex. 52	Ex. 53	Ex. 54	Ex. 55	Ex. 56	Ex. 57
HFO-1132(E)	Mass %	65.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0
HFO-1123	Mass %	7.9	57.9	52.9	47.9	42.9	37.9	32.9	27.9
R1234yf	Mass %	20.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	49	50	50	50	50	50	50	50
COP ratio	% (relative to R410A)	98.6	94.6	94.9	95.2	95.5	95.9	96.3	96.8
Refrigerating capacity ratio	% (relative to R410A)	94.4	97.1	96.9	96.7	96.3	95.9	95.4	94.8

TABLE 57

Item	Unit	Ex. 58	Ex. 59	Ex. 60	Ex. 61	Comp. Ex. 71	Ex. 62	Ex. 63	Ex. 64
HFO-1132(E)	Mass %	45.0	50.0	55.0	60.0	65.0	10.0	15.0	20.0
HFO-1123	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
R1234yf	Mass %	25.0	25.0	25.0	25.0	25.0	30.0	30.0	30.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	50	50	50	50	50	50	50	50
COP ratio	% (relative to R410A)	97.2	97.7	98.2	98.7	99.2	95.2	95.5	95.8
Refrigerating capacity ratio	% (relative to R410A)	94.2	93.6	92.9	92.2	91.4	94.2	93.9	93.7

TABLE 58

Item	Unit	Ex. 65	Ex. 66	Ex. 67	Ex. 68	Ex. 69	Ex. 70	Ex. 71	Ex. 72
HFO-1132(E)	Mass %	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0
HFO-1123	Mass %	37.9	32.9	27.9	22.9	17.9	12.9	7.9	2.9
R1234yf	Mass %	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	50	50	50	50	50	50	50	50
COP ratio	% (relative to R410A)	96.2	96.6	97.0	97.4	97.9	98.3	98.8	99.3
Refrigerating capacity ratio	% (relative to R410A)	93.3	92.9	92.4	91.8	91.2	90.5	89.8	89.1

TABLE 59

Item	Unit	Ex. 73	Ex. 74	Ex. 75	Ex. 76	Ex. 77	Ex. 78	Ex. 79	Ex. 80
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
HFO-1123	Mass %	47.9	42.9	37.9	32.9	27.9	22.9	17.9	12.9
R1234yf	Mass %	35.0	35.0	35.0	35.0	35.0	35.0	35.0	35.0
R32	Mass %	7.1	7.1	7.1	7.1	7.1	7.1	7.1	7.1
GWP	—	50	50	50	50	50	50	50	50
COP ratio	% (relative to R410A)	95.9	96.2	96.5	96.9	97.2	97.7	98.1	98.5

TABLE 64-continued

Item	Unit	Comp.							
		Ex. 97	Ex. 83	Ex. 98	Ex. 99	Ex. 100	Ex. 101	Ex. 102	Ex. 103
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	99	99	99	99	99	99	99	99
COP ratio	% (relative to R410A)	96.2	96.6	94.2	94.4	94.6	94.9	95.2	95.5
Refrigerating capacity ratio	% (relative to R410A)	106.6	106.0	107.5	107.3	107.0	106.6	106.1	105.6

TABLE 65

Item	Unit	Comp.							
		Ex. 104	Ex. 105	Ex. 106	Ex. 84	Ex. 107	Ex. 108	Ex. 109	Ex. 110
HFO-1132(E)	Mass %	40.0	45.0	50.0	55.0	10.0	15.0	20.0	25.0
HFO-1123	Mass %	35.5	30.5	25.5	20.5	60.5	55.5	50.5	45.5
R1234yf	Mass %	10.0	10.0	10.0	10.0	15.0	15.0	15.0	15.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	99	99	99	99	99	99	99	99
COP ratio	% (relative to R410A)	95.9	96.3	96.7	97.1	94.6	94.8	95.1	95.4
Refrigerating capacity ratio	% (relative to R410A)	105.1	104.5	103.8	103.1	104.7	104.5	104.1	103.7

TABLE 66

Item	Unit	Comp.							
		Ex. 111	Ex. 112	Ex. 113	Ex. 114	Ex. 115	Ex. 85	Ex. 116	Ex. 117
HFO-1132(E)	Mass %	30.0	35.0	40.0	45.0	50.0	55.0	10.0	15.0
HFO-1123	Mass %	40.5	35.5	30.5	25.5	20.5	15.5	55.5	50.5
R1234yf	Mass %	15.0	15.0	15.0	15.0	15.0	15.0	20.0	20.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	99	99	99	99	99	99	99	99
COP ratio	% (relative to R410A)	95.7	96.0	96.4	96.8	97.2	97.6	95.1	95.3
Refrigerating capacity ratio	% (relative to R410A)	103.3	102.8	102.2	101.6	101.0	100.3	101.8	101.6

TABLE 67

Item	Unit	Comp.							
		Ex. 118	Ex. 119	Ex. 120	Ex. 121	Ex. 122	Ex. 123	Ex. 124	Ex. 86
HFO-1132(E)	Mass %	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0
HFO-1123	Mass %	45.5	40.5	35.5	30.5	25.5	20.5	15.5	10.5
R1234yf	Mass %	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	99	99	99	99	99	99	99	99
COP ratio	% (relative to R410A)	95.6	95.9	96.2	96.5	96.9	97.3	97.7	98.2
Refrigerating capacity ratio	% (relative to R410A)	101.2	100.8	100.4	99.9	99.3	98.7	98.0	97.3

TABLE 68

Item	Unit	Comp.							
		Ex. 125	Ex. 126	Ex. 127	Ex. 128	Ex. 129	Ex. 130	Ex. 131	Ex. 132
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
HFO-1123	Mass %	50.5	45.5	40.5	35.5	30.5	25.5	20.5	15.5
R1234yf	Mass %	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	99	99	99	99	99	99	99	99
COP ratio	% (relative to R410A)	95.6	95.9	96.1	96.4	96.7	97.1	97.5	97.9

TABLE 68-continued

Item	Unit	Ex. 125	Ex. 126	Ex. 127	Ex. 128	Ex. 129	Ex. 130	Ex. 131	Ex. 132
Refrigerating capacity ratio	% (relative to R410A)	98.9	98.6	98.3	97.9	97.4	96.9	96.3	95.7

TABLE 69

Item	Unit	Comp.							
		Ex. 133	Ex. 87	Ex. 134	Ex. 135	Ex. 136	Ex. 137	Ex. 138	Ex. 139
HFO-1132(E)	Mass %	50.0	55.0	10.0	15.0	20.0	25.0	30.0	35.0
HFO-1123	Mass %	10.5	5.5	45.5	40.5	35.5	30.5	25.5	20.5
R1234yf	Mass %	25.0	25.0	30.0	30.0	30.0	30.0	30.0	30.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	99	99	100	100	100	100	100	100
COP ratio	% (relative to R410A)	98.3	98.7	96.2	96.4	96.7	97.0	97.3	97.7
Refrigerating capacity ratio	% (relative to R410A)	95.0	94.3	95.8	95.6	95.2	94.8	94.4	93.8

TABLE 70

Item	Unit	Ex. 140	Ex. 141	Ex. 142	Ex. 143	Ex. 144	Ex. 145	Ex. 146	Ex. 147
HFO-1132(E)	Mass %	40.0	45.0	50.0	10.0	15.0	20.0	25.0	30.0
HFO-1123	Mass %	15.5	10.5	5.5	40.5	35.5	30.5	25.5	20.5
R1234yf	Mass %	30.0	30.0	30.0	35.0	35.0	35.0	35.0	35.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	100	100	100	100	100	100	100	100
COP ratio	% (relative to R410A)	98.1	98.5	98.9	96.8	97.0	97.3	97.6	97.9
Refrigerating capacity ratio	% (relative to R410A)	93.3	92.6	92.0	92.8	92.5	92.2	91.8	91.3

TABLE 71

Item	Unit	Ex. 148	Ex. 149	Ex. 150	Ex. 151	Ex. 152	Ex. 153	Ex. 154	Ex. 155
HFO-1132(E)	Mass %	35.0	40.0	45.0	10.0	15.0	20.0	25.0	30.0
HFO-1123	Mass %	15.5	10.5	5.5	35.5	30.5	25.5	20.5	15.5
R1234yf	Mass %	35.0	35.0	35.0	40.0	40.0	40.0	40.0	40.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	100	100	100	100	100	100	100	100
COP ratio	% (relative to R410A)	98.3	98.7	99.1	97.4	97.7	98.0	98.3	98.6
Refrigerating capacity ratio	% (relative to R410A)	90.8	90.2	89.6	89.6	89.4	89.0	88.6	88.2

TABLE 72

Item	Unit	Comp.							
		Ex. 156	Ex. 157	Ex. 158	Ex. 159	Ex. 160	Ex. 88	Ex. 89	Ex. 90
HFO-1132(E)	Mass %	35.0	40.0	10.0	15.0	20.0	25.0	30.0	35.0
HFO-1123	Mass %	10.5	5.5	30.5	25.5	20.5	15.5	10.5	5.5
R1234yf	Mass %	40.0	40.0	45.0	45.0	45.0	45.0	45.0	45.0
R32	Mass %	14.5	14.5	14.5	14.5	14.5	14.5	14.5	14.5
GWP	—	100	100	100	100	100	100	100	100
COP ratio	% (relative to R410A)	98.9	99.3	98.1	98.4	98.7	98.9	99.3	99.6
Refrigerating capacity ratio	% (relative to R410A)	87.6	87.1	86.5	86.2	85.9	85.5	85.0	84.5

TABLE 77-continued

Item	Unit	Comp.							
		Ex. 183	Ex. 184	Ex. 98	Ex. 185	Ex. 186	Ex. 187	Ex. 188	Ex. 189
COP ratio	% (relative to R410A)	97.2	97.5	97.9	96.1	96.3	96.5	96.8	97.1
Refrigerating capacity ratio	% (relative to R410A)	103.3	102.6	102.0	103.0	102.7	102.3	101.9	101.4

TABLE 78

Item	Unit	Comp.							
		Ex. 190	Ex. 191	Ex. 192	Ex. 99	Ex. 193	Ex. 194	Ex. 195	Ex. 196
HFO-1132(E)	Mass %	35.0	40.0	45.0	50.0	10.0	15.0	20.0	25.0
HFO-1123	Mass %	23.1	18.1	13.1	8.1	43.1	38.1	33.1	28.1
R1234yf	Mass %	20.0	20.0	20.0	20.0	25.0	25.0	25.0	25.0
R32	Mass %	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
GWP	—	149	149	149	149	149	149	149	149
COP ratio	% (relative to R410A)	97.4	97.7	98.0	98.4	96.6	96.8	97.0	97.3
Refrigerating capacity ratio	% (relative to R410A)	100.9	100.3	99.7	99.1	100.0	99.7	99.4	98.9

TABLE 79

Item	Unit	Comp.							
		Ex. 197	Ex. 198	Ex. 199	Ex. 200	Ex. 100	Ex. 201	Ex. 202	Ex. 203
HFO-1132(E)	Mass %	30.0	35.0	40.0	45.0	50.0	10.0	15.0	20.0
HFO-1123	Mass %	23.1	18.1	13.1	8.1	3.1	38.1	33.1	28.1
R1234yf	Mass %	25.0	25.0	25.0	25.0	25.0	30.0	30.0	30.0
R32	Mass %	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
GWP	—	149	149	149	149	149	150	150	150
COP ratio	% (relative to R410A)	97.6	97.9	98.2	98.5	98.9	97.1	97.3	97.6
Refrigerating capacity ratio	% (relative to R410A)	98.5	97.9	97.4	96.8	96.1	97.0	96.7	96.3

TABLE 80

Item	Unit	Comp.							
		Ex. 204	Ex. 205	Ex. 206	Ex. 207	Ex. 208	Ex. 209	Ex. 210	Ex. 211
HFO-1132(E)	Mass %	25.0	30.0	35.0	40.0	45.0	10.0	15.0	20.0
HFO-1123	Mass %	23.1	18.1	13.1	8.1	3.1	33.1	28.1	23.1
R1234yf	Mass %	30.0	30.0	30.0	30.0	30.0	35.0	35.0	35.0
R32	Mass %	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
GWP	—	150	150	150	150	150	150	150	150
COP ratio	% (relative to R410A)	97.8	98.1	98.4	98.7	99.1	97.7	97.9	98.1
Refrigerating capacity ratio	% (relative to R410A)	95.9	95.4	94.9	94.4	93.8	93.9	93.6	93.3

TABLE 81

Item	Unit	Comp.							
		Ex. 212	Ex. 213	Ex. 214	Ex. 215	Ex. 216	Ex. 217	Ex. 218	Ex. 219
HFO-1132(E)	Mass %	25.0	30.0	35.0	40.0	10.0	15.0	20.0	25.0
HFO-1123	Mass %	18.1	13.1	8.1	3.1	28.1	23.1	18.1	13.1
R1234yf	Mass %	35.0	35.0	35.0	35.0	40.0	40.0	40.0	40.0
R32	Mass %	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
GWP	—	150	150	150	150	150	150	150	150
COP ratio	% (relative to R410A)	98.4	98.7	99.0	99.3	98.3	98.5	98.7	99.0
Refrigerating capacity ratio	% (relative to R410A)	92.9	92.4	91.9	91.3	90.8	90.5	90.2	89.7

TABLE 82

Item	Unit	Ex. 220	Ex. 221	Ex. 222	Ex. 223	Ex. 224	Ex. 225	Ex. 226	Comp. Ex. 101
HFO-1132(E)	Mass %	30.0	35.0	10.0	15.0	20.0	25.0	30.0	10.0
HFO-1123	Mass %	8.1	3.1	23.1	18.1	13.1	8.1	3.1	18.1
R1234yf	Mass %	40.0	40.0	45.0	45.0	45.0	45.0	45.0	50.0
R32	Mass %	21.9	21.9	21.9	21.9	21.9	21.9	21.9	21.9
GWP	—	150	150	150	150	150	150	150	150
COP ratio	% (relative to R410A)	99.3	99.6	98.9	99.1	99.3	99.6	99.9	99.6
Refrigerating capacity ratio	% (relative to R410A)	89.3	88.8	87.6	87.3	87.0	86.6	86.2	84.4

TABLE 83

Item	Unit	Comp. Ex. 102	Comp. Ex. 103	Comp. Ex. 104
HFO-1132(E)	Mass %	15.0	20.0	25.0
HFO-1123	Mass %	13.1	8.1	3.1
R1234yf	Mass %	50.0	50.0	50.0
R32	Mass %	21.9	21.9	21.9
GWP	—	150	150	150

TABLE 83-continued

Item	Unit	Comp. Ex. 102	Comp. Ex. 103	Comp. Ex. 104
COP ratio	% (relative to R410A)	99.8	100.0	100.2
Refrigerating capacity ratio	% (relative to R410A)	84.1	83.8	83.4

TABLE 84

Item	Unit	Ex. 227	Ex. 228	Ex. 229	Ex. 230	Ex. 231	Ex. 232	Ex. 233	Comp. Ex. 105
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
HFO-1123	Mass %	55.7	50.7	45.7	40.7	35.7	30.7	25.7	20.7
R1234yf	Mass %	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	199	199	199	199	199	199	199	199
COP ratio	% (relative to R410A)	95.9	96.0	96.2	96.3	96.6	96.8	97.1	97.3
Refrigerating capacity ratio	% (relative to R410A)	112.2	111.9	111.6	111.2	110.7	110.2	109.6	109.0

TABLE 85

Item	Unit	Ex. 234	Ex. 235	Ex. 236	Ex. 237	Ex. 238	Ex. 239	Ex. 240	Comp. Ex. 106
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
HFO-1123	Mass %	50.7	45.7	40.7	35.7	30.7	25.7	20.7	15.7
R1234yf	Mass %	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	199	199	199	199	199	199	199	199
COP ratio	% (relative to R410A)	96.3	96.4	96.6	96.8	97.0	97.2	97.5	97.8
Refrigerating capacity ratio	% (relative to R410A)	109.4	109.2	108.8	108.4	107.9	107.4	106.8	106.2

TABLE 86

Item	Unit	Ex. 241	Ex. 242	Ex. 243	Ex. 244	Ex. 245	Ex. 246	Ex. 247	Comp. Ex. 107
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
HFO-1123	Mass %	45.7	40.7	35.7	30.7	25.7	20.7	15.7	10.7
R1234yf	Mass %	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	199	199	199	199	199	199	199	199
COP ratio	% (relative to R410A)	96.7	96.8	97.0	97.2	97.4	97.7	97.9	98.2
Refrigerating capacity ratio	% (relative to R410A)	106.6	106.3	106.0	105.5	105.1	104.5	104.0	103.4

TABLE 87

Item	Unit	Ex. 248	Ex. 249	Ex. 250	Ex. 251	Ex. 252	Ex. 253	Ex. 254	Comp. Ex. 108
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0
HFO-1123	Mass %	40.7	35.7	30.7	25.7	20.7	15.7	10.7	5.7
R1234yf	Mass %	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	199	199	199	199	199	199	199	199
COP ratio	% (relative to R410A)	97.1	97.3	97.5	97.7	97.9	98.1	98.4	98.7
Refrigerating capacity ratio	% (relative to R410A)	103.7	103.4	103.0	102.6	102.2	101.6	101.1	100.5

TABLE 88

Item	Unit	Ex. 255	Ex. 256	Ex. 257	Ex. 258	Ex. 259	Ex. 260	Ex. 261	Ex. 262
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	40.0	10.0
HFO-1123	Mass %	35.7	30.7	25.7	20.7	15.7	10.7	5.7	30.7
R1234yf	Mass %	25.0	25.0	25.0	25.0	25.0	25.0	25.0	30.0
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	199	199	199	199	199	199	199	199
COP ratio	% (relative to R410A)	97.6	97.7	97.9	98.1	98.4	98.6	98.9	98.1
Refrigerating capacity ratio	% (relative to R410A)	100.7	100.4	100.1	99.7	99.2	98.7	98.2	97.7

TABLE 89

Item	Unit	Ex. 263	Ex. 264	Ex. 265	Ex. 266	Ex. 267	Ex. 268	Ex. 269	Ex. 270
HFO-1132(E)	Mass %	15.0	20.0	25.0	30.0	35.0	10.0	15.0	20.0
HFO-1123	Mass %	25.7	20.7	15.7	10.7	5.7	25.7	20.7	15.7
R1234yf	Mass %	30.0	30.0	30.0	30.0	30.0	35.0	35.0	35.0
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	199	199	199	199	199	200	200	200
COP ratio	% (relative to R410A)	98.2	98.4	98.6	98.9	99.1	98.6	98.7	98.9
Refrigerating capacity ratio	% (relative to R410A)	97.4	97.1	96.7	96.2	95.7	94.7	94.4	94.0

TABLE 90

Item	Unit	Ex. 271	Ex. 272	Ex. 273	Ex. 274	Ex. 275	Ex. 276	Ex. 277	Ex. 278
HFO-1132(E)	Mass %	25.0	30.0	10.0	15.0	20.0	25.0	10.0	15.0
HFO-1123	Mass %	10.7	5.7	20.7	15.7	10.7	5.7	15.7	10.7
R1234yf	Mass %	35.0	35.0	40.0	40.0	40.0	40.0	45.0	45.0
R32	Mass %	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3
GWP	—	200	200	200	200	200	200	200	200
COP ratio	% (relative to R410A)	99.2	99.4	99.1	99.3	99.5	99.7	99.7	99.8
Refrigerating capacity ratio	% (relative to R410A)	93.6	93.2	91.5	91.3	90.9	90.6	88.4	88.1

TABLE 91

Item	Unit	Ex. 279	Ex. 280	Comp. Ex. 109	Comp. Ex. 110
HFO-1132(E)	Mass %	20.0	10.0	15.0	10.0
HFO-1123	Mass %	5.7	10.7	5.7	5.7
R1234yf	Mass %	45.0	50.0	50.0	55.0
R32	Mass %	29.3	29.3	29.3	29.3
GWP	—	200	200	200	200

TABLE 91-continued

Item	Unit	Ex. 279	Ex. 280	Comp. Ex. 109	Comp. Ex. 110
COP ratio	% (relative to R410A)	100.0	100.3	100.4	100.9
Refrigerating capacity ratio	% (relative to R410A)	87.8	85.2	85.0	82.0

TABLE 92

Item	Unit	Ex. 281	Ex. 282	Ex. 283	Ex. 284	Ex. 285	Comp.		
							Ex. 111	Ex. 286	Ex. 287
HFO-1132(E)	Mass %	10.0	15.0	20.0	25.0	30.0	35.0	10.0	15.0
HFO-1123	Mass %	40.9	35.9	30.9	25.9	20.9	15.9	35.9	30.9
R1234yf	Mass %	5.0	5.0	5.0	5.0	5.0	5.0	10.0	10.0
R32	Mass %	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1
GWP	—	298	298	298	298	298	298	299	299
COP ratio	% (relative to R410A)	97.8	97.9	97.9	98.1	98.2	98.4	98.2	98.2
Refrigerating capacity ratio	% (relative to R410A)	112.5	112.3	111.9	111.6	111.2	110.7	109.8	109.5

TABLE 93

Item	Unit	Ex. 288	Ex. 289	Ex. 290	Ex. 112	Ex. 291	Ex. 292	Ex. 293	Ex. 294
HFO-1132(E)	Mass %	20.0	25.0	30.0	35.0	10.0	15.0	20.0	25.0
HFO-1123	Mass %	25.9	20.9	15.9	10.9	30.9	25.9	20.9	15.9
R1234yf	Mass %	10.0	10.0	10.0	10.0	15.0	15.0	15.0	15.0
R32	Mass %	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1
GWP	—	299	299	299	299	299	299	299	299
COP ratio	% (relative to R410A)	98.3	98.5	98.6	98.8	98.6	98.6	98.7	98.9
Refrigerating capacity ratio	% (relative to R410A)	109.2	108.8	108.4	108.0	107.0	106.7	106.4	106.0

TABLE 94

Item	Unit	Ex. 295	Ex. 113	Ex. 296	Ex. 297	Ex. 298	Ex. 299	Ex. 300	Ex. 301
HFO-1132(E)	Mass %	30.0	35.0	10.0	15.0	20.0	25.0	30.0	10.0
HFO-1123	Mass %	10.9	5.9	25.9	20.9	15.9	10.9	5.9	20.9
R1234yf	Mass %	15.0	15.0	20.0	20.0	20.0	20.0	20.0	25.0
R32	Mass %	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1
GWP	—	299	299	299	299	299	299	299	299
COP ratio	% (relative to R410A)	99.0	99.2	99.0	99.0	99.2	99.3	99.4	99.4
Refrigerating capacity ratio	% (relative to R410A)	105.6	105.2	104.1	103.9	103.6	103.2	102.8	101.2

TABLE 95

Item	Unit	Ex. 302	Ex. 303	Ex. 304	Ex. 305	Ex. 306	Ex. 307	Ex. 308	Ex. 309
HFO-1132(E)	Mass %	15.0	20.0	25.0	10.0	15.0	20.0	10.0	15.0
HFO-1123	Mass %	15.9	10.9	5.9	15.9	10.9	5.9	10.9	5.9
R1234yf	Mass %	25.0	25.0	25.0	30.0	30.0	30.0	35.0	35.0
R32	Mass %	44.1	44.1	44.1	44.1	44.1	44.1	44.1	44.1
GWP	—	299	299	299	299	299	299	299	299
COP ratio	% (relative to R410A)	99.5	99.6	99.7	99.8	99.9	100.0	100.3	100.4
Refrigerating capacity ratio	% (relative to R410A)	101.0	100.7	100.3	98.3	98.0	97.8	95.3	95.1

TABLE 96

Item	Unit	Ex. 400
HFO-1132(E)	Mass %	10.0
HFO-1123	Mass %	5.9
R1234yf	Mass %	40.0
R32	Mass %	44.1
GWP	—	299

TABLE 96-continued

Item	Unit	Ex. 400
COP ratio	% (relative to R410A)	100.7
Refrigerating capacity ratio	% (relative to R410A)	92.3

[0676] The above results indicate that the refrigerating capacity ratio relative to R410A is 85% or more in the following cases:

[0677] When the mass % of HFO-1132(E), HFO-1123, R1234yf, and R32 based on their sum is respectively represented by x, y, z, and a, in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is (100-a) mass %, a straight line connecting a point (0.0, 100.0-a, 0.0) and a point (0.0, 0.0, 100.0-a) is the base, and the point (0.0, 100.0-a, 0.0) is on the left side, if $0 < a \leq 11.1$, coordinates (x,y,z) in the ternary composition diagram are on, or on the left side of, a straight line AB that connects point A (0.0134a²-1.9681a+68.6, 0.0, -0.0134a²+0.9681a+31.4) and point B (0.0, 0.0144a²-1.6377a+58.7, -0.0144a²+0.6377a+41.3);

[0678] if $11.1 < a \leq 18.2$, coordinates (x,y,z) in the ternary composition diagram are on, or on the left side of, a straight line AB that connects point A (0.0112a²-1.9337a+68.484, 0.0, -0.0112a²+0.9337a+31.516) and point B (0.0, 0.0075a²-1.5156a+58.199, -0.0075a²+0.5156a+41.801);

[0679] if $18.2 < a \leq 26.7$, coordinates (x,y,z) in the ternary composition diagram are on, or on the left side of, a straight line AB that connects point A (0.0107a²-1.9142a+68.305, 0.0, -0.0107a²+0.9142a+31.695) and point B (0.0, 0.009a²-1.6045a+59.318, -0.009a²+0.6045a+40.682);

[0680] if $26.7 < a \leq 36.7$, coordinates (x,y,z) in the ternary composition diagram are on, or on the left side of, a straight line AB that connects point A (0.0103a²-1.9225a+68.793, 0.0, -0.0103a²+0.9225a+31.207) and point B (0.0, 0.0046a²-1.41a+57.286, -0.0046a²+0.41a+42.714); and

[0681] if $36.7 < a \leq 46.7$, coordinates (x,y,z) in the ternary composition diagram are on, or on the left side of, a straight line AB that connects point A (0.0085a²-1.8102a+67.1, 0.0, -0.0085a²+0.8102a+32.9) and point B (0.0, 0.0012a²-1.1659a+52.95, -0.0012a²+0.1659a+47.05).

[0682] Actual points having a refrigerating capacity ratio of 85% or more form a curved line that connects point A and point B in FIG. 4, and that extends toward the 1234yf side. Accordingly, when coordinates are on, or on the left side of, the straight line AB, the refrigerating capacity ratio relative to R410A is 85% or more.

[0683] Similarly, it was also found that in the ternary composition diagram, if $0 < a \leq 11.1$, when coordinates (x,y,z) are on, or on the left side of, a straight line D'C that connects point D' (0.0, 0.0224a²+0.968a+75.4, -0.0224a²-1.968a+24.6) and point C (-0.2304a²-0.4062a+32.9, 0.2304a²-0.5938a+67.1, 0.0); or if $11.1 < a \leq 46.7$, when coordinates are in the entire region, the COP ratio relative to that of R410A is 92.5% or more.

[0684] In FIG. 4, the COP ratio of 92.5% or more forms a curved line CD. In FIG. 4, an approximate line formed by connecting three points: point C (32.9, 67.1, 0.0) and points (26.6, 68.4, 5) (19.5, 70.5, 10) where the COP ratio is 92.5% when the concentration of R1234yf is 5 mass % and 10 mass was obtained, and a straight line that connects point C and point D' (0, 75.4, 24.6), which is the intersection of the approximate line and a point where the concentration of HFO-1132(E) is 0.0 mass % was defined as a line segment D'C. In FIG. 5, point D'(0, 83.4, 9.5) was similarly obtained from an approximate curve formed by connecting point C (18.4, 74.5, 0) and points (13.9, 76.5, 2.5) (8.7, 79.2, 5) where the COP ratio is 92.5%, and a straight line that connects point C and point D' was defined as the straight line D'C.

[0685] The composition of each mixture was defined as WCF. A leak simulation was performed using NIST Standard Reference Database REFLEAK Version 4.0 under the conditions of Equipment, Storage, Shipping, Leak, and Recharge according to the ASHRAE Standard 34-2013. The most flammable fraction was defined as WCF.

[0686] For the flammability, the burning velocity was measured according to the ANSI/ASHRAE Standard 34-2013. Both WCF and WCF having a burning velocity of 10 cm/s or less were determined to be classified as "Class 2L (lower flammability)."

[0687] A burning velocity test was performed using the apparatus shown in FIG. 2 in the following manner. First, the mixed refrigerants used had a purity of 99.5% or more, and were degassed by repeating a cycle of freezing, pumping, and thawing until no traces of air were observed on the vacuum gauge. The burning velocity was measured by the closed method. The initial temperature was ambient temperature. Ignition was performed by generating an electric spark between the electrodes in the center of a sample cell. The duration of the discharge was 1.0 to 9.9 ms, and the ignition energy was typically about 0.1 to 1.0 J. The spread of the flame was visualized using schlieren photographs. A cylindrical container (inner diameter: 155 mm, length: 198 mm) equipped with two light transmission acrylic windows was used as the sample cell, and a xenon lamp was used as the light source. Schlieren images of the flame were recorded by a high-speed digital video camera at a frame rate of 600 fps and stored on a PC.

[0688] The results are shown in Tables 97 to 104.

TABLE 97

Item			Comp. Ex. 6	Comp. Ex. 13	Comp. Ex. 19	Comp. Ex. 24	Comp. Ex. 29	Comp. Ex. 34
WCF	HFO-1132(E)	Mass %	72.0	60.9	55.8	52.1	48.6	45.4
	HFO-1123	Mass %	28.0	32.0	33.1	33.4	33.2	32.7
	R1234yf	Mass %	0.0	0.0	0.0	0	0	0
	R32	Mass %	0.0	7.1	11.1	14.5	18.2	21.9
Burning velocity (WCF) cm/s			10	10	10	10	10	10

TABLE 98

Item			Comp. Ex. 39	Comp. Ex. 45	Comp. Ex. 51	Comp. Ex. 57	Comp. Ex. 62
WCF	HFO-1132(E)	Mass %	41.8	40	35.7	32	30.4
	HFO-1123	Mass %	31.5	30.7	23.6	23.9	21.8

TABLE 98-continued

Item		Comp. Ex. 39	Comp. Ex. 45	Comp. Ex. 51	Comp. Ex. 57	Comp. Ex. 62
R1234yf	Mass %	0	0	0	0	0
R32	Mass %	26.7	29.3	36.7	44.1	47.8
Burning velocity (WCF)	cm/s	10	10	10	10	10

TABLE 99

Item		Comp. Ex. 7	Comp. Ex. 14	Comp. Ex. 20	Comp. Ex. 25	Comp. Ex. 30	Comp. Ex. 35	
WCF	HFO-1132(E)	Mass %	72.0	60.9	55.8	52.1	48.6	45.4
	HFO-1123	Mass %	0.0	0.0	0.0	0	0	0
	R1234yf	Mass %	28.0	32.0	33.1	33.4	33.2	32.7
	R32	Mass %	0.0	7.1	11.1	14.5	18.2	21.9
Burning velocity (WCF)	cm/s	10	10	10	10	10	10	

TABLE 100

Item		Comp. Ex. 40	Comp. Ex. 46	Comp. Ex. 52	Comp. Ex. 58	Comp. Ex. 63	
WCF	HFO-1132(E)	Mass %	41.8	40	35.7	32	30.4
	HFO-1123	Mass %	0	0	0	0	0
	R1234yf	Mass %	31.5	30.7	23.6	23.9	21.8
	R32	Mass %	26.7	29.3	36.7	44.1	47.8
Burning velocity (WCF)	cm/s	10	10	10	10	10	

TABLE 101

Item		Comp. Ex. 8	Comp. Ex. 15	Comp. Ex. 21	Comp. Ex. 26	Comp. Ex. 31	Comp. Ex. 36	
WCF	HFO-1132 (E)	Mass %	47.1	40.5	37.0	34.3	32.0	30.3
	HFO-1123	Mass %	52.9	52.4	51.9	51.2	49.8	47.8
	R1234yf	Mass %	0.0	0.0	0.0	0.0	0.0	0.0
	R32	Mass %	0.0	7.1	11.1	14.5	18.2	21.9
Leak condition that results in WCFF		Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	
WCFF	HFO-1132 (E)	Mass %	72.0	62.4	56.2	50.6	45.1	40.0
	HFO-1123	Mass %	28.0	31.6	33.0	33.4	32.5	30.5
	R1234yf	Mass %	0.0	0.0	0.0	20.4	0.0	0.0
	R32	Mass %	0.0	50.9	10.8	16.0	22.4	29.5
Burning velocity (WCF)	cm/s	8 or less	8 or less	8 or less	8 or less	8 or less	8 or less	
Burning velocity (WCFF)	cm/s	10	10	10	10	10	10	

TABLE 102

Item		Comp. Ex. 41	Comp. Ex. 47	Comp. Ex. 53	Comp. Ex. 59	Comp. Ex. 64	
WCF	HFO-1132(E)	Mass %	29.1	28.8	29.3	29.4	28.9
	HFO-1123	Mass %	44.2	41.9	34.0	26.5	23.3
	R1234yf	Mass %	0.0	0.0	0.0	0.0	0.0
	R32	Mass %	26.7	29.3	36.7	44.1	47.8
Leak condition that results in WCFF		Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 90% release, gas phase side	Storage/ Shipping -40° C., 86% release, gas phase side	
WCFF	HFO-1132(E)	Mass %	34.6	32.2	27.7	28.3	27.5
	HFO-1123	Mass %	26.5	23.9	17.5	18.2	16.7
	R1234yf	Mass %	0.0	0.0	0.0	0.0	0.0
	R32	Mass %	38.9	43.9	54.8	53.5	55.8

TABLE 102-continued

Item	Comp. Ex. 41	Comp. Ex. 47	Comp. Ex. 53	Comp. Ex. 59	Comp. Ex. 64	
Burning velocity (WCF)	cm/s	8 or less	8 or less	8.3	9.3	9.6
Burning velocity (WCFF)	cm/s	10	10	10	10	10

TABLE 103

Item	Comp. Ex. 9	Comp. Ex. 16	Comp. Ex. 22	Comp. Ex. 27	Comp. Ex. 32	Comp. Ex. 37	
WCF HFO-1132(E)	Mass %	61.7	47.0	41.0	36.5	32.5	28.8
HFO-1123	Mass %	5.9	7.2	6.5	5.6	4.0	2.4
R1234yf	Mass %	32.4	38.7	41.4	43.4	45.3	46.9
R32	Mass %	0.0	7.1	11.1	14.5	18.2	21.9
Leak condition that results in WCFF	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 92% release, liquid phase side	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side
WCFF HFO-1132(E)	Mass %	72.0	56.2	50.4	46.0	42.4	39.1
HFO-1123	Mass %	10.5	12.6	11.4	10.1	7.4	4.4
R1234yf	Mass %	17.5	20.4	21.8	22.9	24.3	25.7
R32	Mass %	0.0	10.8	16.3	21.0	25.9	30.8
Burning velocity (WCF)	cm/s	8 or less	8 or less	8 or less	8 or less	8 or less	8 or less
Burning velocity (WCFF)	cm/s	10	10	10	10	10	10

TABLE 104

Item	Comp. Ex. 42	Comp. Ex. 48	Comp. Ex. 54	Comp. Ex. 60	Comp. Ex. 65	
WCF HFO-1132(E)	Mass %	24.8	24.3	22.5	21.1	20.4
HFO-1123	Mass %	0.0	0.0	0.0	0.0	0.0
R1234yf	Mass %	48.5	46.4	40.8	34.8	31.8
R32	Mass %	26.7	29.3	36.7	44.1	47.8
Leak conditions that results in WCFF	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side	Storage/ Shipping -40° C., 0% release, gas phase side	
WCFF HFO-1132(E)	Mass %	35.3	34.3	31.3	29.1	28.1
HFO-1123	Mass %	0.0	0.0	0.0	0.0	0.0
R1234yf	Mass %	27.4	26.2	23.1	19.8	18.2
R32	Mass %	37.3	39.6	45.6	51.1	53.7
Burning velocity (WCF)	cm/s	8 or less	8 or less	8 or less	8 or less	8 or less
Burning velocity (WCFF)	cm/s	10	10	10	10	10

[0689] The results in Tables 97 to 100 indicate that the refrigerant has a WCF lower flammability in the following cases:

[0690] When the mass % of HFO-1132(E), HFO-1123, R1234yf, and R32 based on their sum in the mixed refrigerant of HFO-1132(E), HFO-1123, R1234yf, and R32 is respectively represented by x, y, z, and a, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is (100-a) mass % and a straight line connecting a point (0.0, 100.0-a, 0.0) and a point (0.0, 0.0, 100.0-a) is the base, if 0<a≤11.1, coordinates (x,y,z) in the ternary composition diagram are on or below a straight line GI that connects point G (0.026a²-1.7478a+72.0, -0.026a²+0.7478a+28.0, 0.0) and point I (0.026a²-1.7478a+72.0, 0.0, -0.026a²+0.7478a+28.0); if 11.1<a≤18.2, coordinates (x,y,z) in the ternary composition diagram are on or below a straight line GI that connects

point G (0.02a²-1.6013a+71.105, -0.02a²+0.6013a+28.895, 0.0) and point I (0.02a²-1.6013a+71.105, 0.0, -0.02a²+0.6013a+28.895); if 18.2<a≤26.7, coordinates (x,y,z) in the ternary composition diagram are on or below a straight line GI that connects point G (0.0135a²-1.4068a+69.727, -0.0135a²+0.4068a+30.273, 0.0) and point I (0.0135a²-1.4068a+69.727, 0.0, -0.0135a²+0.4068a+30.273); if 26.7<a≤36.7, coordinates (x,y,z) in the ternary composition diagram are on or below a straight line GI that connects point G (0.0111a²-1.3152a+68.986, -0.0111a²+0.3152a+31.014, 0.0) and point I (0.0111a²-1.3152a+68.986, 0.0, -0.0111a²+0.3152a+31.014); and if 36.7<a≤46.7, coordinates (x,y,z) in the ternary composition diagram are on or below a straight line GI that connects point G (0.0061a²-0.9918a+63.902, -0.0061a²-0.0082a+36.098, 0.0) and point I (0.0061a²-0.9918a+63.902, 0.0, -0.0061a²-0.0082a+36.098).

[0691] Three points corresponding to point G (Table 105) and point I (Table 106) were individually obtained in each of the following five ranges by calculation, and their approximate expressions were obtained.

TABLE 105

Item	11.1 ≥ R32 > 0			18.2 ≥ R32 ≥ 11.1			26.7 ≥ R32 ≥ 18.2		
R32	0	7.1	11.1	11.1	14.5	18.2	18.2	21.9	26.7
HFO-1132(E)	72.0	60.9	55.8	55.8	52.1	48.6	48.6	45.4	41.8
HFO-1123	28.0	32.0	33.1	33.1	33.4	33.2	33.2	32.7	31.5
R1234yf	0	0	0	0	0	0	0	0	0
R32	a			a			a		
HFO-1132(E)	0.026a ² - 1.7478a + 72.0			0.02a ² - 1.6013a + 71.105			0.0135a ² - 1.4068a + 69.727		
Approximate expression									
HFO-1123	-0.026a ² + 0.7478a + 28.0			-0.02a ² + 0.6013a + 28.895			-0.0135a ² + 0.4068a + 30.273		
Approximate expression									
R1234yf	0			0			0		
Approximate expression									

Item	36.7 ≥ R32 ≥ 26.7			46.7 ≥ R32 ≥ 36.7		
R32	26.7	29.3	36.7	36.7	44.1	47.8
HFO-1132(E)	41.8	40.0	35.7	35.7	32.0	30.4
HFO-1123	31.5	30.7	27.6	27.6	23.9	21.8
R1234yf	0	0	0	0	0	0
R32	a			a		
HFO-1132(E)	0.0111a ² - 1.3152a + 68.986			0.0061a ² - 0.9918a + 63.902		
Approximate expression						
HFO-1123	-0.0111a ² + 0.3152a + 31.014			-0.0061a ² - 0.0082a + 36.098		
Approximate expression						
R1234yf	0			0		
Approximate expression						

TABLE 106

Item	11.1 ≥ R32 > 0			18.2 ≥ R32 ≥ 11.1			26.7 ≥ R32 ≥ 18.2		
R32	0	7.1	11.1	11.1	14.5	18.2	18.2	21.9	26.7
HFO-1132(E)	72.0	60.9	55.8	55.8	52.1	48.6	48.6	45.4	41.8
HFO-1123	0	0	0	0	0	0	0	0	0
R1234yf	28.0	32.0	33.1	33.1	33.4	33.2	33.2	32.7	31.5
R32	a			a			a		
HFO-1132(E)	0.026a ² - 1.7478a + 72.0			0.02a ² - 1.6013a + 71.105			0.0135a ² - 1.4068a + 69.727		
Approximate expression									
HFO-1123	0			0			0		
Approximate expression									
R1234yf	-0.026a ² + 0.7478a + 28.0			-0.02a ² + 0.6013a + 28.895			-0.0135a ² + 0.4068a + 30.273		
Approximate expression									

Item	36.7 ≥ R32 ≥ 26.7			46.7 ≥ R32 ≥ 36.7		
R32	26.7	29.3	36.7	36.7	44.1	47.8
HFO-1132(E)	41.8	40.0	35.7	35.7	32.0	30.4
HFO-1123	0	0	0	0	0	0
R1234yf	31.5	30.7	23.6	23.6	23.5	21.8
R32	x			x		
HFO-1132(E)	0.0111a ² - 1.3152a + 68.986			0.0061a ² - 0.9918a + 63.902		
Approximate expression						
HFO-1123	0			0		
Approximate expression						
R1234yf	-0.0111a ² + 0.3152a + 31.014			-0.0061a ² - 0.0082a + 36.098		
Approximate expression						

[0692] The results in Tables 101 to 104 indicate that the refrigerant is determined to have a WCFF lower flammability, and the flammability classification according to the ASHRAE Standard is “2L (flammability)” in the following cases:

[0693] When the mass % of HFO-1132(E), HFO-1123, R1234yf, and R32 based on their sum in the mixed refrigerant of HFO-1132(E), HFO-1123, R1234yf, and R32 is respectively represented by x, y, z, and a, in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R1234yf is (100-a) mass % and a straight line connecting a point (0.0, 100.0-a, 0.0) and a point (0.0, 0.0, 100.0-a) is the base, if $0 < a \leq 11.1$, coordinates (x,y,z) in the ternary composition diagram are on or below a straight line JK' that connects point J ($0.0049a^2 - 0.9645a + 47.1$, $-0.0049a^2 - 0.0355a + 52.9$, 0.0) and point K' ($0.0514a^2 - 2.4353a + 61.7$, $-0.0323a^2 + 0.4122a + 5.9$, $-0.0191a^2 + 1.0231a + 32.4$); if $11.1 < a \leq 18.2$, coordinates are on a straight line JK' that connects point J ($0.0243a^2 - 1.4161a + 49.725$, $-0.0243a^2 + 0.4161a + 50.275$, 0.0) and point K' ($0.0341a^2 - 2.1977a + 61.187$, $-0.0236a^2 + 0.34a + 5.636$, $-0.0105a^2 + 0.$

$8577a + 33.177$); if $18.2 < a \leq 26.7$, coordinates are on or below a straight line JK' that connects point J ($0.0246a^2 - 1.4476a + 50.184$, $-0.0246a^2 + 0.4476a + 49.816$, 0.0) and point K' ($0.0196a^2 - 1.7863a + 58.515$, $-0.0079a^2 - 0.1136a + 8.702$, $-0.0117a^2 + 0.8999a + 32.783$); if $26.7 < a \leq 36.7$, coordinates are on or below a straight line JK' that connects point J ($0.0183a^2 - 1.1399a + 46.493$, $-0.0183a^2 + 0.1399a + 53.507$, 0.0) and point K' ($-0.0051a^2 + 0.0929a + 25.95$, 0.0, $0.0051a^2 - 1.0929a + 74.05$); and if $36.7 < a \leq 46.7$, coordinates are on or below a straight line JK' that connects point J ($-0.0134a^2 + 1.0956a + 7.13$, $0.0134a^2 - 2.0956a + 92.87$, 0.0) and point K' ($-1.892a + 29.443$, 0.0, $0.892a + 70.557$).

[0694] Actual points having a WCFF lower flammability form a curved line that connects point J and point K' (on the straight line AB) in FIG. 4 and extends toward the HFO-1132(E) side. Accordingly, when coordinates are on or below the straight line JK', WCFF lower flammability is achieved.

[0695] Three points corresponding to point J (Table 107) and point K' (Table 108) were individually obtained in each of the following five ranges by calculation, and their approximate expressions were obtained.

TABLE 107

Item	11.1 ≥ R32 > 0			18.2 ≥ R32 ≥ 11.1			26.7 ≥ R32 ≥ 18.2		
R32	0	7.1	11.1	11.1	14.5	18.2	18.2	21.9	26.7
HFO-1132(E)	47.1	40.5	37	37.0	34.3	32.0	32.0	30.3	29.1
HFO-1123	52.9	52.4	51.9	51.9	51.2	49.8	49.8	47.8	44.2
R1234yf	0	0	0	0	0	0	0	0	0
R32	a			a			a		
HFO-1132(E)	$0.0049a^2 - 0.9645a + 47.1$			$0.0243a^2 - 1.4161a + 49.725$			$0.0246a^2 - 1.4476a + 50.184$		
Approximate expression									
HFO-1123	$-0.0049a^2 - 0.0355a + 52.9$			$-0.0243a^2 + 0.4161a + 50.275$			$-0.0246a^2 + 0.4476a + 49.816$		
Approximate expression									
R1234yf	0			0			0		
Approximate expression									
Item	36.7 ≥ R32 ≥ 26.7			47.8 ≥ R32 ≥ 36.7					
R32	26.7	29.3	36.7	36.7	44.1	47.8			
HFO-1132(E)	29.1	28.8	29.3	29.3	29.4	28.9			
HFO-1123	44.2	41.9	34.0	34.0	26.5	23.3			
R1234yf	0	0	0	0	0	0			
R32	a			a					
HFO-1132(E)	$0.0183a^2 - 1.1399a + 46.493$			$-0.0134a^2 + 1.0956a + 7.13$					
Approximate expression									
HFO-1123	$-0.0183a^2 + 0.1399a + 53.507$			$0.0134a^2 - 2.0956a + 92.87$					
Approximate expression									
R1234yf	0			0					
Approximate expression									

TABLE 108

Item	11.1 ≥ R32 > 0			18.2 ≥ R32 ≥ 11.1			26.7 ≥ R32 ≥ 18.2		
R32	0	7.1	11.1	11.1	14.5	18.2	18.2	21.9	26.7
HFO-1132(E)	61.7	47.0	41.0	41.0	36.5	32.5	32.5	28.8	24.8
HFO-1123	5.9	7.2	6.5	6.5	5.6	4.0	4.0	2.4	0
R1234yf	32.4	38.7	41.4	41.4	43.4	45.3	45.3	46.9	48.5
R32	x			x			x		
HFO-1132(E)	$0.0514a^2 - 2.4353a + 61.7$			$0.0341a^2 - 2.1977a + 61.187$			$0.0196a^2 - 1.7863a + 58.515$		
Approximate expression									

TABLE 108-continued

HFO-1123 Approximate expression	$-0.0323a^2 + 0.4122a + 5.9$	$-0.0236a^2 + 0.34a + 5.636$	$-0.0079a^2 - 0.1136a + 8.702$
R1234yf Approximate expression	$-0.0191a^2 + 1.0231a + 32.4$	$-0.0105a^2 + 0.8577a + 33.177$	$-0.0117a^2 + 0.8999a + 32.783$
Item	36.7 ≥ R32 ≥ 26.7		46.7 ≥ R32 ≥ 36.7
R32	26.7	29.3	36.7
HFO-1132(E)	24.8	24.3	22.5
HFO-1123	0	0	0
R1234yf	48.5	46.4	40.8
R32	x		x
HFO-1132(E) Approximate expression	$-0.0051a^2 + 0.0929a + 25.95$		$-1.892a + 29.443$
HFO-1123 Approximate expression	0		0
R1234yf Approximate expression	$0.0051a^2 - 1.0929a + 74.05$		$0.892a + 70.557$

[0696] FIGS. 4 to 14 show compositions whose R32 content a (mass %) is 0 mass %, 7.1 mass %, 11.1 mass %, 14.5 mass %, 18.2 mass %, 21.9 mass %, 26.7 mass %, 29.3 mass %, 36.7 mass %, 44.1 mass %, and 47.8 mass %, respectively.

[0697] Points A, B, C, and D' were obtained in the following manner according to approximate calculation.

[0698] Point A is a point where the content of HFO-1123 is 0 mass %, and a refrigerating capacity ratio of 85% relative to that of R410A is achieved. Three points corresponding to point A were obtained in each of the following five ranges by calculation, and their approximate expressions were obtained (Table 109).

TABLE 109

Item	11.1 ≥ R32 > 0			18.2 ≥ R32 ≥ 11.1			26.7 ≥ R32 ≥ 18.2		
R32	0	7.1	11.1	11.1	14.5	18.2	18.2	21.9	26.7
HFO-1132(E)	68.6	55.3	48.4	48.4	42.8	37	37	31.5	24.8
HFO-1123	0	0	0	0	0	0	0	0	0
R1234yf	31.4	37.6	40.5	40.5	42.7	44.8	44.8	46.6	48.5
R32	a			a			a		
HFO-1132(E) Approximate expression	$0.0134a^2 - 1.9681a + 68.6$			$0.0112a^2 - 1.9337a + 68.484$			$0.0107a^2 - 1.9142a + 68.305$		
HFO-1123 Approximate expression	0			0			0		
R1234yf Approximate expression	$-0.0134a^2 + 0.9681a + 31.4$			$-0.0112a^2 + 0.9337a + 31.516$			$-0.0107a^2 + 0.9142a + 31.695$		
Item	36.7 ≥ R32 ≥ 26.7			46.7 ≥ R32 ≥ 36.7					
R32	26.7	29.3	36.7	36.7	44.1	47.8			
HFO-1132(E)	24.8	21.3	12.1	12.1	3.8	0			
HFO-1123	0	0	0	0	0	0			
R1234yf	48.5	49.4	51.2	51.2	52.1	52.2			
R32	a			a					
HFO-1132(E) Approximate expression	$0.0103a^2 - 1.9225a + 68.793$			$0.0085a^2 - 1.8102a + 67.1$					
HFO-1123 Approximate expression	0			0					
R1234yf Approximate expression	$-0.0103a^2 + 0.9225a + 31.207$			$-0.0085a^2 + 0.8102a + 32.9$					

[0699] Point B is a point where the content of HFO-1132 (E) is 0 mass %, and a refrigerating capacity ratio of 85% relative to that of R410A is achieved.

[0700] Three points corresponding to point B were obtained in each of the following five ranges by calculation, and their approximate expressions were obtained (Table 110).

[0703] Point C is a point where the content of R1234yf is 0 mass %, and a COP ratio of 95.5% relative to that of R410A is achieved.

[0704] Three points corresponding to point C were obtained in each of the following by calculation, and their approximate expressions were obtained (Table 112).

TABLE 110

Item	11.1 ≥ R32 > 0			18.2 ≥ R32 ≥ 11.1			26.7 ≥ R32 ≥ 18.2		
R32	0	7.1	11.1	11.1	14.5	18.2	18.2	21.9	26.7
HFO-1132(E)	0	0	0	0	0	0	0	0	0
HFO-1123	58.7	47.8	42.3	42.3	37.8	33.1	33.1	28.5	22.9
R1234yf	41.3	45.1	46.6	46.6	47.7	48.7	48.7	49.6	50.4
R32		a			a			a	
HFO-1132(E)		0			0			0	
Approximate expression									
HFO-1123	0.0144a ² - 1.6377a + 58.7			0.0075a ² - 1.5156a + 58.199			0.009a ² - 1.6045a + 59.318		
Approximate expression									
R1234yf	-0.0144a ² + 0.6377a + 41.3			-0.0075a ² + 0.5156a + 41.801			-0.009a ² + 0.6045a + 40.682		
Approximate expression									
Item	36.7 ≥ R32 ≥ 26.7			46.7 ≥ R32 ≥ 36.7					
R32	26.7	29.3	36.7	36.7	44.1	47.8			
HFO-1132(E)	0	0	0	0	0	0			
HFO-1123	22.9	19.9	11.7	11.8	3.9	0			
R1234yf	50.4	50.8	51.6	51.5	52.0	52.2			
R32		a			a				
HFO-1132(E)		0			0				
Approximate expression									
HFO-1123	0.0046a ² - 1.41a + 57.286			0.0012a ² - 1.1659a + 52.95					
Approximate expression									
R1234yf	-0.0046a ² + 0.41a + 42.714			-0.0012a ² + 0.1659a + 47.05					
Approximate expression									

[0701] Point D' is a point where the content of HFO-1132 (E) is 0 mass %, and a COP ratio of 95.5% relative to that of R410A is achieved.

[0702] Three points corresponding to point D' were obtained in each of the following by calculation, and their approximate expressions were obtained (Table 111).

TABLE 111

Item	11.1 ≥ R32 > 0		
R32	0	7.1	11.1
HFO-1132(E)	0	0	0
HFO-1123	75.4	83.4	88.9
R1234yf	24.6	9.5	0
R32		a	
HFO-1132(E)		0	
Approximate expression			
HFO-1123	0.0224a ² + 0.968a + 75.4		
Approximate expression			
R1234yf	-0.0224a ² - 1.968a + 24.6		
Approximate expression			

TABLE 112

Item	11.1 ≥ R32 > 0		
R32	0	7.1	11.1
HFO-1132(E)	32.9	18.4	0
HFO-1123	67.1	74.5	88.9
R1234yf	0	0	0
R32		a	
HFO-1132(E)	-0.2304a ² - 0.4062a + 32.9		
Approximate expression			
HFO-1123	0.2304a ² - 0.5938a + 67.1		
Approximate expression			
R1234yf	0		
Approximate expression			

(5-4) Refrigerant D

[0705] The refrigerant D according to the present disclosure is a mixed refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), difluoromethane (R32), and 2,3,3,3-tetrafluoro-1-propene (R1234yf).

[0706] The refrigerant D according to the present disclosure has various properties that are desirable as an R410A-alternative refrigerant; i.e., a refrigerating capacity equiva-

lent to that of R410A, a sufficiently low GWP, and a lower flammability (Class 2L) according to the ASHRAE standard.

[0707] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0708] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments IJ, JN, NE, and EI that connect the following 4 points:

point I (72.0, 0.0, 28.0),

point J (48.5, 18.3, 33.2),

point N (27.7, 18.2, 54.1), and

point E (58.3, 0.0, 41.7),

or on these line segments (excluding the points on the line segment EI);

[0709] the line segment IJ is represented by coordinates $(0.0236y^2 - 1.7616y + 72.0, y, -0.0236y^2 + 0.7616y + 28.0)$;

[0710] the line segment NE is represented by coordinates $(0.012y^2 - 1.9003y + 58.3, y, -0.012y^2 + 0.9003y + 41.7)$; and

[0711] the line segments JN and EI are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 80% or more relative to R410A, a GWP of 125 or less, and a WCF lower flammability.

[0712] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0713] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments MM', M'N, NV, VG, and GM that connect the following 5 points:

point M (52.6, 0.0, 47.4),

point M' (39.2, 5.0, 55.8),

point N (27.7, 18.2, 54.1),

point V (11.0, 18.1, 70.9), and

point G (39.6, 0.0, 60.4),

or on these line segments (excluding the points on the line segment GM);

[0714] the line segment MM' is represented by coordinates $(0.132y^2 - 3.34y + 52.6, y, -0.132y^2 + 2.34y + 47.4)$;

[0715] the line segment M'N is represented by coordinates $(0.0596y^2 - 2.2541y + 48.98, y, -0.0596y^2 + 1.2541y + 51.02)$;

[0716] the line segment VG is represented by coordinates $(0.0123y^2 - 1.8033y + 39.6, y, -0.0123y^2 + 0.8033y + 60.4)$; and

[0717] the line segments NV and GM are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 70% or more relative to R410A, a GWP of 125 or less, and an ASHRAE lower flammability.

[0718] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0719] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments ON, NU, and UO that connect the following 3 points:

point O (22.6, 36.8, 40.6),

point N (27.7, 18.2, 54.1), and

point U (3.9, 36.7, 59.4),

or on these line segments;

[0720] the line segment ON is represented by coordinates $(0.0072y^2 - 0.6701y + 37.512, y, -0.0072y^2 - 0.3299y + 62.488)$;

[0721] the line segment NU is represented by coordinates $(0.0083y^2 - 1.7403y + 56.635, y, -0.0083y^2 + 0.7403y + 43.365)$; and

[0722] the line segment UO is a straight line. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 80% or more relative to R410A, a GWP of 250 or less, and an ASHRAE lower flammability.

[0723] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0724] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments QR, RT, TL, LK, and KQ that connect the following 5 points:

point Q (44.6, 23.0, 32.4),

point R (25.5, 36.8, 37.7),

point T (8.6, 51.6, 39.8),

point L (28.9, 51.7, 19.4), and

point K (35.6, 36.8, 27.6),

or on these line segments;

[0725] the line segment QR is represented by coordinates $(0.0099y^2 - 1.975y + 84.765, y, -0.0099y^2 + 0.975y + 15.235)$;

[0726] the line segment RT is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$;

[0727] the line segment LK is represented by coordinates $(0.0049y^2 - 0.8842y + 61.488, y, -0.0049y^2 - 0.1158y + 38.512)$;

[0728] the line segment KQ is represented by coordinates $(0.0095y^2 - 1.2222y + 67.676, y, -0.0095y^2 + 0.2222y + 32.324)$; and

[0729] the line segment TL is a straight line. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 92.5% or more relative to R410A, a GWP of 350 or less, and a WCF lower flammability.

[0730] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0731] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments PS, ST, and TP that connect the following 3 points:

point P (20.5, 51.7, 27.8),

point S (21.9, 39.7, 38.4), and

point T (8.6, 51.6, 39.8),

or on these line segments;

[0732] the line segment PS is represented by coordinates $(0.0064y^2 - 0.7103y + 40.1, y, -0.0064y^2 - 0.2897y + 59.9)$;

[0733] the line segment ST is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$; and

[0734] the line segment TP is a straight line. When the requirements above are satisfied, the refrigerant according to

the present disclosure has a refrigerating capacity ratio of 92.5% or more relative to R410A, a GWP of 350 or less, and an ASHRAE lower flammability.

[0735] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0736] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments ac, cf, fd, and da that connect the following 4 points:

point a (71.1, 0.0, 28.9),
point c (36.5, 18.2, 45.3),
point f (47.6, 18.3, 34.1), and
point d (72.0, 0.0, 28.0),

or on these line segments;

[0737] the line segment ac is represented by coordinates $(0.0181y^2 - 2.2288y + 71.096, y, -0.0181y^2 + 1.2288y + 28.904)$;

[0738] the line segment fd is represented by coordinates $(0.02y^2 - 1.7y + 72, y, -0.02y^2 + 0.7y + 28)$; and

[0739] the line segments cf and da are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to R410A, a GWP of 125 or less, and a lower flammability (Class 2L) according to the ASHRAE standard.

[0740] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0741] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments ab, be, ed, and da that connect the following 4 points:

point a (71.1, 0.0, 28.9),
point b (42.6, 14.5, 42.9),
point e (51.4, 14.6, 34.0), and
point d (72.0, 0.0, 28.0),

or on these line segments;

[0742] the line segment ab is represented by coordinates $(0.0181y^2 - 2.2288y + 71.096, y, -0.0181y^2 + 1.2288y + 28.904)$;

[0743] the line segment ed is represented by coordinates $(0.02y^2 - 1.7y + 72, y, -0.02y^2 + 0.7y + 28)$; and

[0744] the line segments be and da are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 85% or more relative to R410A, a GWP of 100 or less, and a lower flammability (Class 2L) according to the ASHRAE standard.

[0745] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0746] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments gi, ij, and jg that connect the following 3 points:

point g (77.5, 6.9, 15.6),
point i (55.1, 18.3, 26.6), and
point j (77.5, 18.4, 4.1),

or on these line segments;

[0747] the line segment gi is represented by coordinates $(0.02y^2 - 2.4583y + 93.396, y, -0.02y^2 + 1.4583y + 6.604)$; and

[0748] the line segments ij and jg are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 95% or more relative to R410A and a GWP of 100 or less, undergoes fewer or no changes such as polymerization or decomposition, and also has excellent stability.

[0749] The refrigerant D according to the present disclosure is preferably a refrigerant wherein

[0750] when the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments gh, hk, and kg that connect the following 3 points:

point g (77.5, 6.9, 15.6),
point h (61.8, 14.6, 23.6), and
point k (77.5, 14.6, 7.9),

or on these line segments;

[0751] the line segment gh is represented by coordinates $(0.02y^2 - 2.4583y + 93.396, y, -0.02y^2 + 1.4583y + 6.604)$; and

[0752] the line segments hk and kg are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a refrigerating capacity ratio of 95% or more relative to R410A and a GWP of 100 or less, undergoes fewer or no changes such as polymerization or decomposition, and also has excellent stability.

[0753] The refrigerant D according to the present disclosure may further comprise other additional refrigerants in addition to HFO-1132(E), R32, and R1234yf, as long as the above properties and effects are not impaired. In this respect, the refrigerant according to the present disclosure preferably comprises HFO-1132(E), R32, and R1234yf in a total amount of 99.5 mass % or more, more preferably 99.75 mass % or more, and still more preferably 99.9 mass % or more based on the entire refrigerant.

[0754] Such additional refrigerants are not limited, and can be selected from a wide range of refrigerants. The mixed refrigerant may comprise a single additional refrigerant, or two or more additional refrigerants.

(Examples of Refrigerant D)

[0755] The present disclosure is described in more detail below with reference to Examples of refrigerant D. However, the refrigerant D is not limited to the Examples.

[0756] The composition of each mixed refrigerant of HFO-1132(E), R32, and R1234yf was defined as WCF. A leak simulation was performed using the NIST Standard Reference Database REFLEAK Version 4.0 under the conditions of Equipment, Storage, Shipping, Leak, and Recharge according to the ASHRAE Standard 34-2013. The most flammable fraction was defined as WCFF.

[0757] A burning velocity test was performed using the apparatus shown in FIG. 2 in the following manner. First, the mixed refrigerants used had a purity of 99.5% or more, and were degassed by repeating a cycle of freezing, pumping, and thawing until no traces of air were observed on the vacuum gauge. The burning velocity was measured by the closed method. The initial temperature was ambient temperature. Ignition was performed by generating an electric

spark between the electrodes in the center of a sample cell. The duration of the discharge was 1.0 to 9.9 ms, and the ignition energy was typically about 0.1 to 1.0 J. The spread of the flame was visualized using schlieren photographs. A cylindrical container (inner diameter: 155 mm, length: 198 mm) equipped with two light transmission acrylic windows was used as the sample cell, and a xenon lamp was used as the light source. Schlieren images of the flame were recorded by a high-speed digital video camera at a frame rate of 600 fps and stored on a PC. Tables 113 to 115 show the results.

coordinates (x,y,z) in the ternary composition diagram shown in FIG. 15 in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are on the line segment that connects point I, point J, point K, and point L, or below these line segments, the refrigerant has a WCF lower flammability.

[0759] The results also indicate that when coordinates (x,y,z) in the ternary composition diagram shown in FIG. 15 are on the line segments that connect point M, point M',

TABLE 113

Item	Unit	Comparative Example 13	Example 11	Example 12	Example 13	Example 14	Example 15	Example 16
WCF HFO-1132 (E)	Mass %	72	57.2	48.5	41.2	35.6	32	28.9
R32	Mass %	0	10	18.3	27.6	36.8	44.2	51.7
R1234yf	Mass %	28	32.8	33.2	31.2	27.6	23.8	19.4
Burning Velocity (WCF)	cm/s	10	10	10	10	10	10	10

TABLE 114

Item	Unit	Comparative Example 14	Example 18	Example 19	Example 20	Example 21	Example 22
WCF HFO-1132 (E)	Mass %	52.6	39.2	32.4	29.3	27.7	24.6
R32	Mass %	0.0	5.0	10.0	14.5	18.2	27.6
R1234yf	Mass %	47.4	55.8	57.6	56.2	54.1	47.8
Leak condition that results in WCFF		Storage, Shipping, -40° C., 0% release, on the gas phase side	Storage, Shipping, -40° C., 0% release, on the gas phase side	Storage, Shipping, -40° C., 0% release, on the gas phase side	Storage, Shipping, -40° C., 0% release, on the gas phase side	Storage, Shipping, -40° C., 0% release, on the gas phase side	Storage, Shipping, -40° C., 0% release, on the gas phase side
WCF HFO-1132 (E)	Mass %	72.0	57.8	48.7	43.6	40.6	34.9
R32	Mass %	0.0	9.5	17.9	24.2	28.7	38.1
R1234yf	Mass %	28.0	32.7	33.4	32.2	30.7	27.0
Burning Velocity (WCF)	cm/s	8 or less	8 or less	8 or less	8 or less	8 or less	8 or less
Burning Velocity (WCFF)	cm/s	10	10	10	10	10	10

TABLE 115

Item	Unit	Example 23	Example 24	Example 25
WCF HFO-1132 (E)	Mass %	22.6	21.2	20.5
HFO-1123	Mass %	36.8	44.2	51.7
R1234yf	Mass %	40.6	34.6	27.8
Leak condition that results in WCFF		Storage, Shipping, -40° C., 0% release, on the gas phase side	Storage, Shipping, -40° C., 0% release, on the gas phase side	Storage, Shipping, -40° C., 0% release, on the gas phase side
WCFF HFO-1132 (E)	Mass %	31.4	29.2	27.1
HFO-1123	Mass %	45.7	51.1	56.4
R1234yf	Mass %	23.0	19.7	16.5
Burning Velocity (WCF)	cm/s	8 or less	8 or less	8 or less
Burning Velocity (WCFF)	cm/s	10	10	10

[0758] The results indicate that under the condition that the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, when

point W, point J, point N, and point P, or below these line segments, the refrigerant has an ASHRAE lower flammability.

[0760] Mixed refrigerants were prepared by mixing HFO-1132(E), R32, and R1234yf in amounts (mass %) shown in Tables 116 to 144 based on the sum of HFO-1132(E), R32, and R1234yf. The coefficient of performance (COP) ratio and the refrigerating capacity ratio relative to R410 of the mixed refrigerants shown in Tables 116 to 144 were determined. The conditions for calculation were as described below.

[0761] Evaporating temperature: 5° C.
 [0762] Condensation temperature: 45° C.
 [0763] Degree of superheating: 5 K
 [0764] Degree of subcooling: 5 K
 [0765] Compressor efficiency: 70%
 [0766] Tables 116 to 144 show these values together with the GWP of each mixed
 [0767] refrigerant.

TABLE 116

Item	Unit	Comparative Example 1	Comparative	Comparative	Comparative	Comparative	Comparative	Comparative
			Example 2	Example 3	Example 4	Example 5	Example 6	Example 7
			A	B	A'	B'	A''	B''
HFO-1132(E)	Mass %	R410A	81.6	0.0	63.1	0.0	48.2	0.0
R32	Mass %		18.4	18.1	36.9	36.7	51.8	51.5
R1234yf	Mass %		0.0	81.9	0.0	63.3	0.0	48.5
GWP	—	2088	125	125	250	250	350	350
COP Ratio	% (relative to R410A)	100	98.7	103.6	98.7	102.3	99.2	102.2
Refrigerating Capacity Ratio	% (relative to R410A)	100	105.3	62.5	109.9	77.5	112.1	87.3

TABLE 117

Item	Unit	Comparative	Comparative	Comparative	Example	Example	Example	
		Example 8	Example 9	Example 10	1	2	3	4
		C	C'	C'	R	R	T	
HFO-1132(E)	Mass %	85.5	66.1	52.1	37.8	25.5	16.6	8.6
R32	Mass %	0.0	10.0	18.2	27.6	36.8	44.2	51.6
R1234yf	Mass %	14.5	23.9	29.7	34.6	37.7	39.2	39.8
GWP	—	1	69	125	188	250	300	350
COP Ratio	% (relative to R410A)	99.8	99.3	99.3	99.6	100.2	100.8	101.4
Refrigerating Capacity Ratio	% (relative to R410A)	92.5	92.5	92.5	92.5	92.5	92.5	92.5

TABLE 118

Item	Unit	Comparative	Example	Example	Example	Example	Comparative	Example	Example
		Example 11	5	6	7	8	Example 12	9	10
		E	N	N	U	U	G	V	V
HFO-1132(E)	Mass %	58.3	40.5	27.7	14.9	3.9	39.6	22.8	11.0
R32	Mass %	0.0	10.0	18.2	27.6	36.7	0.0	10.0	18.1
R1234yf	Mass %	41.7	49.5	54.1	57.5	59.4	60.4	67.2	70.9
GWP	—	2	70	125	189	250	3	70	125
COP Ratio	% (relative to R410A)	100.3	100.3	100.7	101.2	101.9	101.4	101.8	102.3
Refrigerating Capacity Ratio	% (relative to R410A)	80.0	80.0	80.0	80.0	80.0	70.0	70.0	70.0

TABLE 119

Item	Unit	Comparative	Example	Example	Example	Example	Example	Example	Example
		Example 13	11	12	13	14	Example 15	16	17
		I	J	J	K	K	L	L	Q
HFO-1132(E)	Mass %	72.0	57.2	48.5	41.2	35.6	32.0	28.9	44.6
R32	Mass %	0.0	10.0	18.3	27.6	36.8	44.2	51.7	23.0
R1234yf	Mass %	28.0	32.8	33.2	31.2	27.6	23.8	19.4	32.4
GWP	—	2	69	125	188	250	300	350	157
COP Ratio	% (relative to R410A)	99.9	99.5	99.4	99.5	99.6	99.8	100.1	99.4
Refrigerating Capacity Ratio	% (relative to R410A)	86.6	88.4	90.9	94.2	97.7	100.5	103.3	92.5

TABLE 120

Item	Unit	Comparative Example 14 M	Example 18	Example 19 W	Example 20	Example 21 N	Example 22
HFO-1132(E)	Mass %	52.6	39.2	32.4	29.3	27.7	24.5
R32	Mass %	0.0	5.0	10.0	14.5	18.2	27.6
R1234yf	Mass %	47.4	55.8	57.6	56.2	54.1	47.9
GWP	—	2	36	70	100	125	188
COP Ratio	% (relative to R410A)	100.5	100.9	100.9	100.8	100.7	100.4
Refrigerating Capacity Ratio	% (relative to R410A)	77.1	74.8	75.6	77.8	80.0	85.5

TABLE 121

Item	Unit	Example 23 O	Example 24	Example 25 P	Example 26 S
HFO-1132(E)	Mass %	22.6	21.2	20.5	21.9
R32	Mass %	36.8	44.2	51.7	39.7
R1234yf	Mass %	40.6	34.6	27.8	38.4
GWP	—	250	300	350	270

TABLE 121-continued

Item	Unit	Example 23 O	Example 24	Example 25 P	Example 26 S
COP Ratio	%(relative to R410A)	100.4	100.5	100.6	100.4
Refrigerating Capacity Ratio	%(relative to R410A)	91.0	95.0	99.1	92.5

TABLE 122

Item	Unit	Comparative Example 15	Comparative Example 16	Comparative Example 17	Comparative Example 18	Example 27	Example 28	Comparative Example 19	Comparative Example 20
HFO-1132(E)	Mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0
R32	Mass %	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
R1234yf	Mass %	85.0	75.0	65.0	55.0	45.0	35.0	25.0	15.0
GWP	—	37	37	37	36	36	36	35	35
COP Ratio	% (relative to R410A)	103.4	102.6	101.6	100.8	100.2	99.8	99.6	99.4
Refrigerating Capacity Ratio	% (relative to R410A)	56.4	63.3	69.5	75.2	80.5	85.4	90.1	94.4

TABLE 123

Item	Unit	Comparative Example 21	Comparative Example 22	Example 29	Comparative Example 23	Example 30	Comparative Example 24	Comparative Example 25	Comparative Example 26
HFO-1132(E)	Mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0
R32	Mass %	10.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
R1234yf	Mass %	80.0	70.0	60.0	50.0	40.0	30.0	20.0	10.0
GWP	—	71	71	70	70	70	69	69	69
COP Ratio	% (relative to R410A)	103.1	102.1	101.1	100.4	99.8	99.5	99.2	99.1
Refrigerating Capacity Ratio	% (relative to R410A)	61.8	68.3	74.3	79.7	84.9	89.7	94.2	98.4

TABLE 124

Item	Unit	Comparative Example 27	Example 31	Comparative Example 28	Example 32	Example 33	Comparative Example 29	Comparative Example 30	Comparative Example 31
HFO-1132(E)	Mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0
R32	Mass %	15.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
R1234yf	Mass %	75.0	65.0	55.0	45.0	35.0	25.0	15.0	5.0
GWP	—	104	104	104	103	103	103	103	102
COP Ratio	% (relative to R410A)	102.7	101.6	100.7	100.0	99.5	99.2	99.0	98.9
Refrigerating Capacity Ratio	% (relative to R410A)	66.6	72.9	78.6	84.0	89.0	93.7	98.1	102.2

TABLE 125

Item	Unit	Comparative Example 32	Comparative Example 33	Comparative Example 34	Comparative Example 35	Comparative Example 36	Comparative Example 37	Comparative Example 38	Comparative Example 39
HFO-1132(E)	Mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	10.0
R32	Mass %	20.0	20.0	20.0	20.0	20.0	20.0	20.0	25.0
R1234yf	Mass %	70.0	60.0	50.0	40.0	30.0	20.0	10.0	65.0
GWP	—	138	138	137	137	137	136	136	171
COP Ratio	% (relative to R410A)	102.3	101.2	100.4	99.7	99.3	99.0	98.8	101.9
Refrigerating Capacity Ratio	% (relative to R410A)	71.0	77.1	82.7	88.0	92.9	97.5	101.7	75.0

TABLE 126

Item	Unit	Example 34	Comparative Example 40	Comparative Example 41	Comparative Example 42	Comparative Example 43	Comparative Example 44	Comparative Example 45	Example 35
HFO-1132(E)	Mass %	20.0	30.0	40.0	50.0	60.0	70.0	10.0	20.0
R32	Mass %	25.0	25.0	25.0	25.0	25.0	25.0	30.0	30.0
R1234yf	Mass %	55.0	45.0	35.0	25.0	15.0	5.0	60.0	50.0
GWP	—	171	171	171	170	170	170	205	205
COP Ratio	% (relative to R410A)	100.9	100.1	99.6	99.2	98.9	98.7	101.6	100.7
Refrigerating Capacity Ratio	% (relative to R410A)	81.0	86.6	91.7	96.5	101.0	105.2	78.9	84.8

TABLE 127

Item	Unit	Comparative Example 46	Comparative Example 47	Comparative Example 48	Comparative Example 49	Example 36	Example 37	Example 38	Comparative Example 50
HFO-1132(E)	Mass %	30.0	40.0	50.0	60.0	10.0	20.0	30.0	40.0
R32	Mass %	30.0	30.0	30.0	30.0	35.0	35.0	35.0	35.0
R1234yf	Mass %	40.0	30.0	20.0	10.0	55.0	45.0	35.0	25.0
GWP	—	204	204	204	204	239	238	238	238
COP Ratio	% (relative to R410A)	100.0	99.5	99.1	98.8	101.4	100.6	99.9	99.4
Refrigerating Capacity Ratio	% (relative to R410A)	90.2	95.3	100.0	104.4	82.5	88.3	93.7	98.6

TABLE 128

Item	Unit	Comparative Example 51	Comparative Example 52	Comparative Example 53	Comparative Example 54	Example 39	Comparative Example 55	Comparative Example 56	Comparative Example 57
HFO-1132(E)	Mass %	50.0	60.0	10.0	20.0	30.0	40.0	50.0	10.0
R32	Mass %	35.0	35.0	40.0	40.0	40.0	40.0	40.0	45.0
R1234yf	Mass %	15.0	5.0	50.0	40.0	30.0	20.0	10.0	45.0
GWP	—	237	237	272	272	272	271	271	306
COP Ratio	% (relative to R410A)	99.0	98.8	101.3	100.6	99.9	99.4	99.0	101.3
Refrigerating Capacity Ratio	% (relative to R410A)	103.2	107.5	86.0	91.7	96.9	101.8	106.3	89.3

TABLE 129

Item	Unit	Example 40	Example 41	Comparative Example 58	Comparative Example 59	Comparative Example 60	Example 42	Comparative Example 61	Comparative Example 62
HFO-1132(E)	Mass %	20.0	30.0	40.0	50.0	10.0	20.0	30.0	40.0
R32	Mass %	45.0	45.0	45.0	45.0	50.0	50.0	50.0	50.0
R1234yf	Mass %	35.0	25.0	15.0	5.0	40.0	30.0	20.0	10.0
GWP	—	305	305	305	304	339	339	339	338
COP Ratio	% (relative to R410A)	100.6	100.0	99.5	99.1	101.3	100.6	100.0	99.5
Refrigerating Capacity Ratio	% (relative to R410A)	94.9	100.0	104.7	109.2	92.4	97.8	102.9	107.5

TABLE 130

Item	Unit	Comparative Example 63	Comparative Example 64	Comparative Example 65	Comparative Example 66	Example 43	Example 44	Example 45	Example 46
HFO-1132(E)	Mass %	10.0	20.0	30.0	40.0	56.0	59.0	62.0	65.0
R32	Mass %	55.0	55.0	55.0	55.0	3.0	3.0	3.0	3.0
R1234yf	Mass %	35.0	25.0	15.0	5.0	41.0	38.0	35.0	32.0
GWP	—	373	372	372	372	22	22	22	22
COP Ratio	% (relative to R410A)	101.4	100.7	100.1	99.6	100.1	100.0	99.9	99.8
Refrigerating Capacity Ratio	% (relative to R410A)	95.3	100.6	105.6	110.2	81.7	83.2	84.6	86.0

TABLE 131

Item	Unit	Example 47	Example 48	Example 49	Example 50	Example 51	Example 52	Example 53	Example 54
HFO-1132(E)	Mass %	49.0	52.0	55.0	58.0	61.0	43.0	46.0	49.0
R32	Mass %	6.0	6.0	6.0	6.0	6.0	9.0	9.0	9.0
R1234yf	Mass %	45.0	42.0	39.0	36.0	33.0	48.0	45.0	42.0
GWP	—	43	43	43	43	42	63	63	63
COP Ratio	% (relative to R410A)	100.2	100.0	99.9	99.8	99.7	100.3	100.1	99.9
Refrigerating Capacity Ratio	% (relative to R410A)	80.9	82.4	83.9	85.4	86.8	80.4	82.0	83.5

TABLE 132

Item	Unit	Example 55	Example 56	Example 57	Example 58	Example 59	Example 60	Example 61	Example 62
HFO-1132(E)	Mass %	52.0	55.0	58.0	38.0	41.0	44.0	47.0	50.0
R32	Mass %	9.0	9.0	9.0	12.0	12.0	12.0	12.0	12.0
R1234yf	Mass %	39.0	36.0	33.0	50.0	47.0	44.0	41.0	38.0
GWP	—	63	63	63	83	83	83	83	83
COP Ratio	% (relative to R410A)	99.8	99.7	99.6	100.3	100.1	100.0	99.8	99.7
Refrigerating Capacity Ratio	% (relative to R410A)	85.0	86.5	87.9	80.4	82.0	83.5	85.1	86.6

TABLE 133

Item	Unit	Example 63	Example 64	Example 65	Example 66	Example 67	Example 68	Example 69	Example 70
HFO-1132(E)	Mass %	53.0	33.0	36.0	39.0	42.0	45.0	48.0	51.0
R32	Mass %	12.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
R1234yf	Mass %	35.0	52.0	49.0	46.0	43.0	40.0	37.0	34.0
GWP	—	83	104	104	103	103	103	103	103
COP Ratio	% (relative to R410A)	99.6	100.5	100.3	100.1	99.9	99.7	99.6	99.5
Refrigerating Capacity Ratio	% (relative to R410A)	88.0	80.3	81.9	83.5	85.0	86.5	88.0	89.5

TABLE 134

Item	Unit	Example 71	Example 72	Example 73	Example 74	Example 75	Example 76	Example 77	Example 78
HFO-1132(E)	Mass %	29.0	32.0	35.0	38.0	41.0	44.0	47.0	36.0
R32	Mass %	18.0	18.0	18.0	18.0	18.0	18.0	18.0	3.0
R1234yf	Mass %	53.0	50.0	47.0	44.0	41.0	38.0	35.0	61.0
GWP	—	124	124	124	124	124	123	123	23
COP Ratio	% (relative to R410A)	100.6	100.3	100.1	99.9	99.8	99.6	99.5	101.3
Refrigerating Capacity Ratio	% (relative to R410A)	80.6	82.2	83.8	85.4	86.9	88.4	89.9	71.0

TABLE 135

Item	Unit	Example 79	Example 80	Example 81	Example 82	Example 83	Example 84	Example 85	Example 86
HFO-1132(E)	Mass %	39.0	42.0	30.0	33.0	36.0	26.0	29.0	32.0
R32	Mass %	3.0	3.0	6.0	6.0	6.0	9.0	9.0	9.0
R1234yf	Mass %	58.0	55.0	64.0	61.0	58.0	65.0	62.0	59.0
GWP	—	23	23	43	43	43	64	64	63
COP Ratio	% (relative to R410A)	101.1	100.9	101.5	101.3	101.0	101.6	101.3	101.1
Refrigerating Capacity Ratio	% (relative to R410A)	72.7	74.4	70.5	72.2	73.9	71.0	72.8	74.5

TABLE 136

Item	Unit	Example 87	Example 88	Example 89	Example 90	Example 91	Example 92	Example 93	Example 94
HFO-1132(E)	Mass %	21.0	24.0	27.0	30.0	16.0	19.0	22.0	25.0
R32	Mass %	12.0	12.0	12.0	12.0	15.0	15.0	15.0	15.0
R1234yf	Mass %	67.0	64.0	61.0	58.0	69.0	66.0	63.0	60.0
GWP	—	84	84	84	84	104	104	104	104
COP Ratio	% (relative to R410A)	101.8	101.5	101.2	101.0	102.1	101.8	101.4	101.2
Refrigerating Capacity Ratio	% (relative to R410A)	70.8	72.6	74.3	76.0	70.4	72.3	74.0	75.8

TABLE 137

Item	Unit	Example 95	Example 96	Example 97	Example 98	Example 99	Example 100	Example 101	Example 102
HFO-1132(E)	Mass %	28.0	12.0	15.0	18.0	21.0	24.0	27.0	25.0
R32	Mass %	15.0	18.0	18.0	18.0	18.0	18.0	18.0	21.0
R1234yf	Mass %	57.0	70.0	67.0	64.0	61.0	58.0	55.0	54.0
GWP	—	104	124	124	124	124	124	124	144
COP Ratio	% (relative to R410A)	100.9	102.2	101.9	101.6	101.3	101.0	100.7	100.7
Refrigerating Capacity Ratio	% (relative to R410A)	77.5	70.5	72.4	74.2	76.0	77.7	79.4	80.7

TABLE 138

Item	Unit	Example 103	Example 104	Example 105	Example 106	Example 107	Example 108	Example 109	Example 110
HFO-1132(E)	Mass %	21.0	24.0	17.0	20.0	23.0	13.0	16.0	19.0
R32	Mass %	24.0	24.0	27.0	27.0	27.0	30.0	30.0	30.0
R1234yf	Mass %	55.0	52.0	56.0	53.0	50.0	57.0	54.0	51.0
GWP	—	164	164	185	185	184	205	205	205
COP Ratio	% (relative to R410A)	100.9	100.6	101.1	100.8	100.6	101.3	101.0	100.8
Refrigerating Capacity Ratio	% (relative to R410A)	80.8	82.5	80.8	82.5	84.2	80.7	82.5	84.2

TABLE 139

Item	Unit	Example 111	Example 112	Example 113	Example 114	Example 115	Example 116	Example 117	Example 118
HFO-1132(E)	Mass %	22.0	9.0	12.0	15.0	18.0	21.0	8.0	12.0
R32	Mass %	30.0	33.0	33.0	33.0	33.0	33.0	36.0	36.0
R1234yf	Mass %	48.0	58.0	55.0	52.0	49.0	46.0	56.0	52.0
GWP	—	205	225	225	225	225	225	245	245
COP Ratio	% (relative to R410A)	100.5	101.6	101.3	101.0	100.8	100.5	101.6	101.2
Refrigerating Capacity Ratio	% (relative to R410A)	85.9	80.5	82.3	84.1	85.8	87.5	82.0	84.4

TABLE 140

Item	Unit	Example 119	Example 120	Example 121	Example 122	Example 123	Example 124	Example 125	Example 126
HFO-1132(E)	Mass %	15.0	18.0	21.0	42.0	39.0	34.0	37.0	30.0
R32	Mass %	36.0	36.0	36.0	25.0	28.0	31.0	31.0	34.0
R1234yf	Mass %	49.0	46.0	43.0	33.0	33.0	35.0	32.0	36.0
GWP	—	245	245	245	170	191	211	211	231
COP Ratio	% (relative to R410A)	101.0	100.7	100.5	99.5	99.5	99.8	99.6	99.9
Refrigerating Capacity Ratio	% (relative to R410A)	86.2	87.9	89.6	92.7	93.4	93.0	94.5	93.0

TABLE 141

Item	Unit	Example 127	Example 128	Example 129	Example 130	Example 131	Example 132	Example 133	Example 134
HFO-1132(E)	Mass %	33.0	36.0	24.0	27.0	30.0	33.0	23.0	26.0
R32	Mass %	34.0	34.0	37.0	37.0	37.0	37.0	40.0	40.0
R1234yf	Mass %	33.0	30.0	39.0	36.0	33.0	30.0	37.0	34.0
GWP	—	231	231	252	251	251	251	272	272
COP Ratio	% (relative to R410A)	99.8	99.6	100.3	100.1	99.9	99.8	100.4	100.2
Refrigerating Capacity Ratio	% (relative to R410A)	94.5	96.0	91.9	93.4	95.0	96.5	93.3	94.9

TABLE 142

Item	Unit	Example 135	Example 136	Example 137	Example 138	Example 139	Example 140	Example 141	Example 142
HFO-1132(E)	Mass %	29.0	32.0	19.0	22.0	25.0	28.0	31.0	18.0
R32	Mass %	40.0	40.0	43.0	43.0	43.0	43.0	43.0	46.0
R1234yf	Mass %	31.0	28.0	38.0	35.0	32.0	29.0	26.0	36.0
GWP	—	272	271	292	292	292	292	292	312
COP Ratio	% (relative to R410A)	100.0	99.8	100.6	100.4	100.2	100.1	99.9	100.7
Refrigerating Capacity Ratio	% (relative to R410A)	96.4	97.9	93.1	94.7	96.2	97.8	99.3	94.4

TABLE 143

Item	Unit	Example 143	Example 144	Example 145	Example 146	Example 147	Example 148	Example 149	Example 150
HFO-1132(E)	Mass %	21.0	23.0	26.0	29.0	13.0	16.0	19.0	22.0
R32	Mass %	46.0	46.0	46.0	46.0	49.0	49.0	49.0	49.0
R1234yf	Mass %	33.0	31.0	28.0	25.0	38.0	35.0	32.0	29.0
GWP	—	312	312	312	312	332	332	332	332
COP Ratio	% (relative to R410A)	100.5	100.4	100.2	100.0	101.1	100.9	100.7	100.5
Refrigerating Capacity Ratio	% (relative to R410A)	96.0	97.0	98.6	100.1	93.5	95.1	96.7	98.3

TABLE 144

Item	Unit	Example 151	Example 152
HFO-1132(E)	Mass %	25.0	28.0
R32	Mass %	49.0	49.0
R1234yf	Mass %	26.0	23.0
GWP	—	332	332
COP Ratio	%(relative to R410A)	100.3	100.1
Refrigerating Capacity Ratio	%(relative to R410A)	99.8	101.3

[0768] The results also indicate that under the condition that the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, when coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments IJ, JN, NE, and EI that connect the following 4 points:
 point I (72.0, 0.0, 28.0),
 point J (48.5, 18.3, 33.2),
 point N (27.7, 18.2, 54.1), and
 point E (58.3, 0.0, 41.7),

or on these line segments (excluding the points on the line segment EI),

[0769] the line segment IJ is represented by coordinates $(0.0236y^2-1.7616y+72.0, y, -0.0236y^2+0.7616y+28.0)$,

[0770] the line segment NE is represented by coordinates $(0.012y^2-1.9003y+58.3, y, -0.012y^2+0.9003y+41.7)$, and

[0771] the line segments JN and EI are straight lines, the refrigerant D has a refrigerating capacity ratio of 80% or more relative to R410A, a GWP of 125 or less, and a WCF lower flammability.

[0772] The results also indicate that under the condition that the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, when coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments MM', M'N, NV, VG, and GM that connect the following 5 points:

point M (52.6, 0.0, 47.4),

point M' (39.2, 5.0, 55.8),

point N (27.7, 18.2, 54.1),

point V (11.0, 18.1, 70.9), and

point G (39.6, 0.0, 60.4),

or on these line segments (excluding the points on the line segment GM),

[0773] the line segment MM' is represented by coordinates $(0.132y^2-3.34y+52.6, y, -0.132y^2+2.34y+47.4)$,

[0774] the line segment M'N is represented by coordinates $(0.0596y^2-2.2541y+48.98, y, -0.0596y^2+1.2541y+51.02)$,

[0775] the line segment VG is represented by coordinates $(0.0123y^2-1.8033y+39.6, y, -0.0123y^2+0.8033y+60.4)$, and

[0776] the line segments NV and GM are straight lines, the refrigerant D according to the present disclosure has a refrigerating capacity ratio of 70% or more relative to R410A, a GWP of 125 or less, and an ASHRAE lower flammability.

[0777] The results also indicate that under the condition that the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, when coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments ON, NU, and UO that connect the following 3 points:

point O (22.6, 36.8, 40.6),

point N (27.7, 18.2, 54.1), and

point U (3.9, 36.7, 59.4),

or on these line segments,

[0778] the line segment ON is represented by coordinates $(0.0072y^2-0.6701y+37.512, y, -0.0072y^2-0.3299y+62.488)$,

[0779] the line segment NU is represented by coordinates $(0.0083y^2-1.7403y+56.635, y, -0.0083y^2+0.7403y+43.365)$, and

[0780] the line segment UO is a straight line, the refrigerant D according to the present disclosure has a refrigerating capacity ratio of 80% or more relative to R410A, a GWP of 250 or less, and an ASHRAE lower flammability.

[0781] The results also indicate that under the condition that the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, when coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100

mass % are within the range of a figure surrounded by line segments QR, RT, TL, LK, and KQ that connect the following 5 points:

point Q (44.6, 23.0, 32.4),

point R (25.5, 36.8, 37.7),

point T (8.6, 51.6, 39.8),

point L (28.9, 51.7, 19.4), and

point K (35.6, 36.8, 27.6),

or on these line segments,

[0782] the line segment QR is represented by coordinates $(0.0099y^2-1.975y+84.765, y, -0.0099y^2+0.975y+15.235)$,

[0783] the line segment RT is represented by coordinates $(0.0082y^2-1.8683y+83.126, y, -0.0082y^2+0.8683y+16.874)$,

[0784] the line segment LK is represented by coordinates $(0.0049y^2-0.8842y+61.488, y, -0.0049y^2-0.1158y+38.512)$,

[0785] the line segment KQ is represented by coordinates $(0.0095y^2-1.2222y+67.676, y, -0.0095y^2+0.2222y+32.324)$, and

[0786] the line segment TL is a straight line, the refrigerant D according to the present disclosure has a refrigerating capacity ratio of 92.5% or more relative to R410A, a GWP of 350 or less, and a WCF lower flammability.

[0787] The results further indicate that under the condition that the mass % of HFO-1132(E), R32, and R1234yf based on their sum is respectively represented by x, y, and z, when coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), R32, and R1234yf is 100 mass % are within the range of a figure surrounded by line segments PS, ST, and TP that connect the following 3 points:

point P (20.5, 51.7, 27.8),

point S (21.9, 39.7, 38.4), and

point T (8.6, 51.6, 39.8),

or on these line segments,

[0788] the line segment PS is represented by coordinates $(0.0064y^2-0.7103y+40.1, y, -0.0064y^2-0.2897y+59.9)$,

[0789] the line segment ST is represented by coordinates $(0.0082y^2-1.8683y+83.126, y, -0.0082y^2+0.8683y+16.874)$, and

[0790] the line segment TP is a straight line, the refrigerant D according to the present disclosure has a refrigerating capacity ratio of 92.5% or more relative to R410A, a GWP of 350 or less, and an ASHRAE lower flammability.

(5-5) Refrigerant E

[0791] The refrigerant E according to the present disclosure is a mixed refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and difluoromethane (R32).

[0792] The refrigerant E according to the present disclosure has various properties that are desirable as an R410A-alternative refrigerant, i.e., a coefficient of performance equivalent to that of R410A and a sufficiently low GWP.

[0793] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0794] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments IK, KB', B'H, HR, RG, and GI that connect the following 6 points:

point I (72.0, 28.0, 0.0),
 point K (48.4, 33.2, 18.4),
 point B' (0.0, 81.6, 18.4),
 point H (0.0, 84.2, 15.8),
 point R (23.1, 67.4, 9.5), and
 point G (38.5, 61.5, 0.0),

or on these line segments (excluding the points on the line segments B'H and GI);

[0795] the line segment IK is represented by coordinates $(0.025z^2 - 1.7429z + 72.00, -0.025z^2 + 0.7429z + 28.0, z)$,

[0796] the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$,

[0797] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

[0798] the line segments KB' and GI are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has WCF lower flammability, a COP ratio of 93% or more relative to that of R410A, and a GWP of 125 or less.

[0799] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0800] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments IJ, JR, RG, and GI that connect the following 4 points:

point I (72.0, 28.0, 0.0),
 point J (57.7, 32.8, 9.5),
 point R (23.1, 67.4, 9.5), and
 point G (38.5, 61.5, 0.0),

or on these line segments (excluding the points on the line segment GI);

[0801] the line segment IJ is represented by coordinates $(0.025z^2 - 1.7429z + 72.0, -0.025z^2 + 0.7429z + 28.0, z)$,

[0802] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

[0803] the line segments JR and GI are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has WCF lower flammability, a COP ratio of 93% or more relative to that of R410A, and a GWP of 125 or less.

[0804] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0805] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments MP, PB', B'H, HR, RG, and GM that connect the following 6 points:

point M (47.1, 52.9, 0.0),
 point P (31.8, 49.8, 18.4),
 point B' (0.0, 81.6, 18.4),
 point H (0.0, 84.2, 15.8),
 point R (23.1, 67.4, 9.5), and
 point G (38.5, 61.5, 0.0),

or on these line segments (excluding the points on the line segments B'H and GM);

[0806] the line segment MP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,

[0807] the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$,

[0808] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

[0809] the line segments PB' and GM are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has ASHRAE lower flammability, a COP ratio of 93% or more relative to that of R410A, and a GWP of 125 or less.

[0810] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0811] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments MN, NR, RG, and GM that connect the following 4 points:

point M (47.1, 52.9, 0.0),
 point N (38.5, 52.1, 9.5),
 point R (23.1, 67.4, 9.5), and
 point G (38.5, 61.5, 0.0),

or on these line segments (excluding the points on the line segment GM);

[0812] the line segment MN is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,

[0813] the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$,

[0814] the line segments NR and GM are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has ASHRAE lower flammability, a COP ratio of 93% or more relative to that of R410A, and a GWP of 65 or less.

[0815] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0816] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments PS, ST, and TP that connect the following 3 points:

point P (31.8, 49.8, 18.4),
 point S (25.4, 56.2, 18.4), and
 point T (34.8, 51.0, 14.2),

or on these line segments;

[0817] the line segment ST is represented by coordinates $(-0.0982z^2 + 0.9622z + 40.931, 0.0982z^2 - 1.9622z + 59.069, z)$,

[0818] the line segment TP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$, and

[0819] the line segment PS is a straight line. When the requirements above are satisfied, the refrigerant according to the present disclosure has ASHRAE lower flammability, a COP ratio of 94.5% or more relative to that of R410A, and a GWP of 125 or less.

[0820] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0821] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments QB", B"D, DU, and UQ that connect the following 4 points:

point Q (28.6, 34.4, 37.0),
 point B" (0.0, 63.0, 37.0),
 point D (0.0, 67.0, 33.0), and
 point U (28.7, 41.2, 30.1),

or on these line segments (excluding the points on the line segment B"D);

[0822] the line segment DU is represented by coordinates $(-3.4962z^2+210.71z-3146.1, 3.4962z^2-211.71z+3246.1, z)$,

[0823] the line segment UQ is represented by coordinates $(0.0135z^2-0.9181z+44.133, -0.0135z^2-0.0819z+55.867, z)$, and

[0824] the line segments QB" and B"D are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has ASHRAE lower flammability, a COP ratio of 96% or more relative to that of R410A, and a GWP of 250 or less.

[0825] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0826] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments Oc', c'd', d'e', e'a', and a'O that connect the following 5 points:

point O (100.0, 0.0, 0.0),
 point c' (56.7, 43.3, 0.0),
 point d' (52.2, 38.3, 9.5),
 point e' (41.8, 39.8, 18.4), and
 point a' (81.6, 0.0, 18.4),

or on the line segments c'd', d'e', and e'a' (excluding the points c' and a');

[0827] the line segment c'd' is represented by coordinates $(-0.0297z^2-0.1915z+56.7, 0.0297z^2+1.1915z+43.3, z)$,

[0828] the line segment d'e' is represented by coordinates $(-0.0535z^2+0.3229z+53.957, 0.0535z^2+0.6771z+46.043, z)$, and

[0829] the line segments Oc', e'a', and a'O are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a COP ratio of 92.5% or more relative to that of R410A, and a GWP of 125 or less.

[0830] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0831] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments Oc, cd, de, ea', and a'O that connect the following 5 points:

point O (100.0, 0.0, 0.0),
 point c (77.7, 22.3, 0.0),
 point d (76.3, 14.2, 9.5),
 point e (72.2, 9.4, 18.4), and
 point a' (81.6, 0.0, 18.4),

or on the line segments cd, de, and ea' (excluding the points c and a');

[0832] the line segment cde is represented by coordinates $(-0.017z^2+0.0148z+77.684, 0.017z^2+0.9852z+22.316, z)$, and

[0833] the line segments Oc, ea', and a'O are straight lines. When the requirements above are satisfied, the refrigerant

according to the present disclosure has a COP ratio of 95% or more relative to that of R410A, and a GWP of 125 or less.

[0834] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0835] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments Oc', c'd', d'a, and aO that connect the following 5 points:

point O (100.0, 0.0, 0.0),
 point c' (56.7, 43.3, 0.0),
 point d' (52.2, 38.3, 9.5), and
 point a (90.5, 0.0, 9.5),

or on the line segments c'd' and d'a (excluding the points c' and a);

[0836] the line segment c'd' is represented by coordinates $(-0.0297z^2-0.1915z+56.7, 0.0297z^2+1.1915z+43.3, z)$, and

[0837] the line segments Oc', d'a, and aO are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a COP ratio of 93.5% or more relative to that of R410A, and a GWP of 65 or less.

[0838] The refrigerant E according to the present disclosure is preferably a refrigerant wherein

[0839] when the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass % are within the range of a figure surrounded by line segments Oc, cd, da, and aO that connect the following 4 points:

point O (100.0, 0.0, 0.0),
 point c (77.7, 22.3, 0.0),
 point d (76.3, 14.2, 9.5), and
 point a (90.5, 0.0, 9.5),

or on the line segments cd and da (excluding the points c and a);

[0840] the line segment cd is represented by coordinates $(-0.017z^2+0.0148z+77.684, 0.017z^2+0.9852z+22.316, z)$, and

[0841] the line segments Oc, da, and aO are straight lines. When the requirements above are satisfied, the refrigerant according to the present disclosure has a COP ratio of 95% or more relative to that of R410A, and a GWP of 65 or less.

[0842] The refrigerant E according to the present disclosure may further comprise other additional refrigerants in addition to HFO-1132(E), HFO-1123, and R32, as long as the above properties and effects are not impaired. In this respect, the refrigerant according to the present disclosure preferably comprises HFO-1132(E), HFO-1123, and R32 in a total amount of 99.5 mass % or more, more preferably 99.75 mass % or more, and even more preferably 99.9 mass % or more, based on the entire refrigerant.

[0843] Such additional refrigerants are not limited, and can be selected from a wide range of refrigerants. The mixed refrigerant may comprise a single additional refrigerant, or two or more additional refrigerants.

(Examples of Refrigerant E)

[0844] The present disclosure is described in more detail below with reference to Examples of refrigerant E. However, the refrigerant E is not limited to the Examples.

[0845] Mixed refrigerants were prepared by mixing HFO-1132(E), HFO-1123, and R32 at mass % based on their sum shown in Tables 145 and 146.

[0846] The composition of each mixture was defined as WCF. A leak simulation was performed using National Institute of Science and Technology (NIST) Standard Reference Data Base Refleak Version 4.0 under the conditions for equipment, storage, shipping, leak, and recharge according to the ASHRAE Standard 34-2013. The most flammable fraction was defined as WCF.

[0847] For each mixed refrigerant, the burning velocity was measured according to the ANSI/ASHRAE Standard 34-2013. When the burning velocities of the WCF composition and the WCF composition are 10 cm/s or less, the flammability of such a refrigerant is classified as Class 2L (lower flammability) in the ASHRAE flammability classification.

[0848] A burning velocity test was performed using the apparatus shown in FIG. 2 in the following manner. First, the mixed refrigerants used had a purity of 99.5% or more, and were degassed by repeating a cycle of freezing, pumping, and thawing until no traces of air were observed on the vacuum gauge. The burning velocity was measured by the closed method. The initial temperature was ambient temperature. Ignition was performed by generating an electric spark between the electrodes in the center of a sample cell. The duration of the discharge was 1.0 to 9.9 ms, and the ignition energy was typically about 0.1 to 1.0 J. The spread of the flame was visualized using schlieren photographs. A cylindrical container (inner diameter: 155 mm, length: 198 mm) equipped with two light transmission acrylic windows was used as the sample cell, and a xenon lamp was used as the light source. Schlieren images of the flame were recorded by a high-speed digital video camera at a frame rate of 600 fps and stored on a PC.

[0849] Tables 145 and 146 show the results.

TABLE 145

Item	Unit	I	J	K	L	
WCF	HFO-1132(E)	mass %	72.0	57.7	48.4	35.5
	HFO-1123	mass %	28.0	32.8	33.2	27.5
	R32	mass %	0.0	9.5	18.4	37.0
Burning velocity (WCF)	cm/s	10	10	10	10	

[0850] The results in Table 1 indicate that in a ternary composition diagram of a mixed refrigerant of HFO-1132 (E), HFO-1123, and R32 in which their sum is 100 mass %, a line segment connecting a point (0.0, 100.0, 0.0) and a point (0.0, 0.0, 100.0) is the base, the point (0.0, 100.0, 0.0) is on the left side, and the point (0.0, 0.0, 100.0) is on the right side, when coordinates (x,y,z) are on or below line segments IK and KL that connect the following 3 points:

point I (72.0, 28.0, 0.0),

point K (48.4, 33.2, 18.4), and

point L (35.5, 27.5, 37.0);

the line segment IK is represented by coordinates $(0.025z^2-1.7429z+72.00, -0.025z^2+0.7429z+28.00, z)$, and

the line segment KL is represented by coordinates $(0.0098z^2-1.238z+67.852, -0.0098z^2+0.238z+32.148, z)$,

it can be determined that the refrigerant has WCF lower flammability.

[0851] For the points on the line segment 1K, an approximate curve $(x=0.025z^2-1.7429z+72.00)$ was obtained from three points, i.e., I (72.0, 28.0, 0.0), J (57.7, 32.8, 9.5), and K (48.4, 33.2, 18.4) by using the least-square method to determine coordinates $(x=0.025z^2-1.7429z+72.00, y=100-z-x=-0.00922z^2+0.2114z+32.443, z)$.

[0852] Likewise, for the points on the line segment KL, an approximate curve was determined from three points, i.e., K (48.4, 33.2, 18.4), Example 10 (41.1, 31.2, 27.7), and L (35.5, 27.5, 37.0) by using the least-square method to determine coordinates.

[0853] The results in Table 146 indicate that in a ternary composition diagram of a mixed refrigerant of HFO-1132 (E), HFO-1123, and R32 in which their sum is 100 mass %, a line segment connecting a point (0.0, 100.0, 0.0) and a point (0.0, 0.0, 100.0) is the base, the point (0.0, 100.0, 0.0) is on the left side, and the point (0.0, 0.0, 100.0) is on the right side, when coordinates (x,y,z) are on or below line segments MP and PQ that connect the following 3 points:

point M (47.1, 52.9, 0.0),

point P (31.8, 49.8, 18.4), and

point Q (28.6, 34.4, 37.0),

it can be determined that the refrigerant has ASHRAE lower flammability.

[0854] In the above, the line segment MP is represented by coordinates $(0.0083z^2-0.984z+47.1, -0.0083z^2-0.016z+52.9, z)$, and the line segment PQ is represented by coordinates $(0.0135z^2-0.9181z+44.133, -0.0135z^2-0.0819z+55.867, z)$.

TABLE 146

Item	Unit	M	N	T	P	U	Q
WCF	HFO-1132(E)	mass %	47.1	38.5	34.8	31.8	28.7
	HFO-1123	mass %	52.9	52.1	51.0	49.8	41.2
	R32	mass %	0.0	9.5	14.2	18.4	30.1
Leak condition that results in WCF		Storage, Shipping, -40° C., 92% release, on the liquid phase side	Storage, Shipping, -40° C., 92% release, on the liquid phase side	Storage, Shipping, -40° C., 92% release, on the liquid phase side	Storage, Shipping, -40° C., 92% release, on the liquid phase side	Storage, Shipping, -40° C., 92% release, on the liquid phase side	Storage, Shipping, -40° C., 92% release, on the liquid phase side
WCF	HFO-1132(E)	mass %	72.0	58.9	51.5	44.6	31.4
	HFO-1123	mass %	28.0	32.4	33.1	32.6	23.2
	R32	mass %	0.0	8.7	15.4	22.8	45.4
Burning velocity (WCF)	cm/s	8 or less	8 or less	8 or less	8 or less	8 or less	8 or less
Burning velocity (WCF)	cm/s	10	10	10	10	10	10

[0855] For the points on the line segment MP, an approximate curve was obtained from three points, i.e., points M, N, and P, by using the least-square method to determine coordinates. For the points on the line segment PQ, an approximate curve was obtained from three points, i.e., points P, U, and Q, by using the least-square method to determine coordinates.

[0856] The GWP of compositions each comprising a mixture of R410A (R32=50%/R125=50%) was evaluated based on the values stated in the Intergovernmental Panel on Climate Change (IPCC), fourth report. The GWP of HFO-1132(E), which was not stated therein, was assumed to be 1 from HFO-1132a (GWP=1 or less) and HFO-1123 (GWP=0.3, described in Patent Literature 1). The refrigerating capacity of compositions each comprising R410A and a mixture of HFO-1132(E) and HFO-1123 was determined by per-

forming theoretical refrigeration cycle calculations for the mixed refrigerants using the National Institute of Science and Technology (NIST) and Reference Fluid Thermodynamic and Transport Properties Database (Refprop 9.0) under the following conditions.

[0857] The COP ratio and the refrigerating capacity (which may be referred to as “cooling capacity” or “capacity”) ratio relative to those of R410 of the mixed refrigerants were determined. The conditions for calculation were as described below.

Evaporating temperature: 5° C.

Condensation temperature: 45° C.

Degree of superheating: 5K

Degree of subcooling: 5K

Compressor efficiency: 70%

[0858] Tables 147 to 166 show these values together with the GWP of each mixed refrigerant.

TABLE 147

Item	Unit	Comparative	Comparative	Comparative	Comparative	Comparative	Comparative	
		Example 1	Example 2 A	Example 3 B	Example 4 A'	Example 5 B'	Example 6 A''	Example 7 B''
HFO-1132(E)	mass %	R410A	90.5	0.0	81.6	0.0	63.0	0.0
HFO-1123	mass %		0.0	90.5	0.0	81.6	0.0	63.0
R32	mass %		9.5	9.5	18.4	18.4	37.0	37.0
GWP	—	2088	65	65	125	125	250	250
COP ratio	% (relative to R410A)	100	99.1	92.0	98.7	93.4	98.7	96.1
Refrigerating capacity ratio	% (relative to R410A)	100	102.2	111.6	105.3	113.7	110.0	115.4

TABLE 148

Item	Unit	Comparative	Comparative	Comparative	Example	Example	Comparative
		Example 8 O	Example 9 C		Example 10 U		Example 11 D
HFO-1132(E)	mass %	100.0	50.0	41.1	28.7	15.2	0.0
HFO-1123	mass %	0.0	31.6	34.6	41.2	52.7	67.0
R32	mass %	0.0	18.4	24.3	30.1	32.1	33.0
GWP	—	1	125	165	204	217	228
COP ratio	% (relative to R410A)	99.7	96.0	96.0	96.0	96.0	96.0
Refrigerating capacity ratio	% (relative to R410A)	98.3	109.9	111.7	113.5	114.8	115.4

TABLE 149

Item	Unit	Comparative	Comparative	Example	Example	Comparative
		Example 12 E		Example 13 T	Example 3 S	Example 4 S
HFO-1132(E)	mass %	53.4	43.4	34.8	25.4	0.0
HFO-1123	mass %	46.6	47.1	51.0	56.2	74.1
R32	mass %	0.0	9.5	14.2	18.4	25.9
GWP	—	1	65	97	125	176
COP ratio	% (relative to R410A)	94.5	94.5	94.5	94.5	94.5
Refrigerating capacity ratio	% (relative to R410A)	105.6	109.2	110.8	112.3	114.8

TABLE 150

Item	Unit	Comparative Example 15 G	Example 5	Example 6 R	Example 7	Comparative Example 16 H
HFO-1132(E)	mass %	38.5	31.5	23.1	16.9	0.0
HFO-1123	mass %	61.5	63.5	67.4	71.1	84.2
R32	mass %	0.0	5.0	9.5	12.0	15.8
GWP	—	1	35	65	82	107
COP ratio	% (relative to R410A)	93.0	93.0	93.0	93.0	93.0
Refrigerating capacity ratio	% (relative to R410A)	107.0	109.1	110.9	111.9	113.2

TABLE 151

Item	Unit	Comparative Example 17 I	Example 8 J	Example 9 K	Comparative Example 18	Comparative Example 19 L
HFO-1132(E)	mass %	72.0	57.7	48.4	41.1	35.5
HFO-1123	mass %	28.0	32.8	33.2	31.2	27.5
R32	mass %	0.0	9.5	18.4	27.7	37.0
GWP	—	1	65	125	188	250
COP ratio	% (relative to R410A)	96.6	95.8	95.9	96.4	97.1
Refrigerating capacity ratio	% (relative to R410A)	103.1	107.4	110.1	112.1	113.2

TABLE 152

Item	Unit	Comparative Example 20 M	Example 10 N	Example 11 P	Example 12 Q
HFO-1132(E)	mass %	47.1	38.5	31.8	28.6
HFO-1123	mass %	52.9	52.1	49.8	34.4
R32	mass %	0.0	9.5	18.4	37.0
GWP	—	1	65	125	250

TABLE 152-continued

Item	Unit	Comparative Example 20 M	Example 10 N	Example 11 P	Example 12 Q
COP ratio	% (relative to R410A)	93.9	94.1	94.7	96.9
Refrigerating capacity ratio	% (relative to R410A)	106.2	109.7	112.0	114.1

TABLE 153

Item	Unit	Comparative Example 22	Comparative Example 23	Comparative Example 24	Example 14	Example 15	Example 16	Comparative Example 25	Comparative Example 26
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	80.0
HFO-1123	mass %	85.0	75.0	65.0	55.0	45.0	35.0	25.0	15.0
R32	mass %	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
GWP	—	35	35	35	35	35	35	35	35
COP ratio	% (relative to R410A)	91.7	92.2	92.9	93.7	94.6	95.6	96.7	97.7
Refrigerating capacity ratio	% (relative to R410A)	110.1	109.8	109.2	108.4	107.4	106.1	104.7	103.1

TABLE 154

Item	Unit	Comparative Example 27	Comparative Example 28	Comparative Example 29	Example 17	Example 18	Example 19	Comparative Example 30	Comparative Example 31
HFO-1132(E)	mass %	90.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0
HFO-1123	mass %	5.0	80.0	70.0	60.0	50.0	40.0	30.0	20.0
R32	mass %	5.0	10.0	10.0	10.0	10.0	10.0	10.0	10.0
GWP	—	35	68	68	68	68	68	68	68
COP ratio	% (relative to R410A)	98.8	92.4	92.9	93.5	94.3	95.1	96.1	97.0
Refrigerating capacity ratio	% (relative to R410A)	101.4	111.7	111.3	110.6	109.6	108.5	107.2	105.7

TABLE 155

Item	Unit	Comparative Example 32	Example 20	Example 21	Example 22	Example 23	Example 24	Comparative Example 33	Comparative Example 34
HFO-1132(E)	mass %	80.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0
HFO-1123	mass %	10.0	75.0	65.0	55.0	45.0	35.0	25.0	15.0
R32	mass %	10.0	15.0	15.0	15.0	15.0	15.0	15.0	15.0
GWP	—	68	102	102	102	102	102	102	102
COP ratio	% (relative to R410A)	98.0	93.1	93.6	94.2	94.9	95.6	96.5	97.4
Refrigerating capacity ratio	% (relative to R410A)	104.1	112.9	112.4	111.6	110.6	109.4	108.1	106.6

TABLE 156

Item	Unit	Comparative Example 35	Comparative Example 36	Comparative Example 37	Comparative Example 38	Comparative Example 39	Comparative Example 40	Comparative Example 41	Comparative Example 42
HFO-1132(E)	mass %	80.0	10.0	20.0	30.0	40.0	50.0	60.0	70.0
HFO-1123	mass %	5.0	70.0	60.0	50.0	40.0	30.0	20.0	10.0
R32	mass %	15.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0
GWP	—	102	136	136	136	136	136	136	136
COP ratio	% (relative to R410A)	98.3	93.9	94.3	94.8	95.4	96.2	97.0	97.8
Refrigerating capacity ratio	% (relative to R410A)	105.0	113.8	113.2	112.4	111.4	110.2	108.8	107.3

TABLE 157

Item	Unit	Comparative Example 43	Comparative Example 44	Comparative Example 45	Comparative Example 46	Comparative Example 47	Comparative Example 48	Comparative Example 49	Comparative Example 50
HFO-1132(E)	mass %	10.0	20.0	30.0	40.0	50.0	60.0	70.0	10.0
HFO-1123	mass %	65.0	55.0	45.0	35.0	25.0	15.0	5.0	60.0
R32	mass %	25.0	25.0	25.0	25.0	25.0	25.0	25.0	30.0
GWP	—	170	170	170	170	170	170	170	203
COP ratio	% (relative to R410A)	94.6	94.9	95.4	96.0	96.7	97.4	98.2	95.3
Refrigerating capacity ratio	% (relative to R410A)	114.4	113.8	113.0	111.9	110.7	109.4	107.9	114.8

TABLE 158

Item	Unit	Comparative Example 51	Comparative Example 52	Comparative Example 53	Comparative Example 54	Comparative Example 55	Example 25	Example 26	Comparative Example 56
HFO-1132(E)	mass %	20.0	30.0	40.0	50.0	60.0	10.0	20.0	30.0
HFO-1123	mass %	50.0	40.0	30.0	20.0	10.0	55.0	45.0	35.0
R32	mass %	30.0	30.0	30.0	30.0	30.0	35.0	35.0	35.0
GWP	—	203	203	203	203	203	237	237	237
COP ratio	% (relative to R410A)	95.6	96.0	96.6	97.2	97.9	96.0	96.3	96.6
Refrigerating capacity ratio	% (relative to R410A)	114.2	113.4	112.4	111.2	109.8	115.1	114.5	113.6

TABLE 159

Item	Unit	Comparative Example 57	Comparative Example 58	Comparative Example 59	Comparative Example 60	Comparative Example 61	Comparative Example 62	Comparative Example 63	Comparative Example 64
HFO-1132(E)	mass %	40.0	50.0	60.0	10.0	20.0	30.0	40.0	50.0
HFO-1123	mass %	25.0	15.0	5.0	50.0	40.0	30.0	20.0	10.0
R32	mass %	35.0	35.0	35.0	40.0	40.0	40.0	40.0	40.0
GWP	—	237	237	237	271	271	271	271	271
COP ratio	% (relative to R410A)	97.1	97.7	98.3	96.6	96.9	97.2	97.7	98.2
Refrigerating capacity ratio	% (relative to R410A)	112.6	111.5	110.2	115.1	114.6	113.8	112.8	111.7

TABLE 160

Item	Unit	Example 27	Example 28	Example 29	Example 30	Example 31	Example 32	Example 33	Example 34
HFO-1132(E)	mass %	38.0	40.0	42.0	44.0	35.0	37.0	39.0	41.0
HFO-1123	mass %	60.0	58.0	56.0	54.0	61.0	59.0	57.0	55.0
R32	mass %	2.0	2.0	2.0	2.0	4.0	4.0	4.0	4.0
GWP	—	14	14	14	14	28	28	28	28
COP ratio	% (relative to R410A)	93.2	93.4	93.6	93.7	93.2	93.3	93.5	93.7
Refrigerating capacity ratio	% (relative to R410A)	107.7	107.5	107.3	107.2	108.6	108.4	108.2	108.0

TABLE 161

Item	Unit	Example 35	Example 36	Example 37	Example 38	Example 39	Example 40	Example 41	Example 42
HFO-1132(E)	mass %	43.0	31.0	33.0	35.0	37.0	39.0	41.0	27.0
HFO-1123	mass %	53.0	63.0	61.0	59.0	57.0	55.0	53.0	65.0
R32	mass %	4.0	6.0	6.0	6.0	6.0	6.0	6.0	8.0
GWP	—	28	41	41	41	41	41	41	55
COP ratio	% (relative to R410A)	93.9	93.1	93.2	93.4	93.6	93.7	93.9	93.0
Refrigerating capacity ratio	% (relative to R410A)	107.8	109.5	109.3	109.1	109.0	108.8	108.6	110.3

TABLE 162

Item	Unit	Example 43	Example 44	Example 45	Example 46	Example 47	Example 48	Example 49	Example 50
HFO-1132(E)	mass %	29.0	31.0	33.0	35.0	37.0	39.0	32.0	32.0
HFO-1123	mass %	63.0	61.0	59.0	57.0	55.0	53.0	51.0	50.0
R32	mass %	8.0	8.0	8.0	8.0	8.0	8.0	17.0	18.0
GWP	—	55	55	55	55	55	55	116	122
COP ratio	% (relative to R410A)	93.2	93.3	93.5	93.6	93.8	94.0	94.5	94.7
Refrigerating capacity ratio	% (relative to R410A)	110.1	110.0	109.8	109.6	109.5	109.3	111.8	111.9

TABLE 163

Item	Unit	Example 51	Example 52	Example 53	Example 54	Example 55	Example 56	Example 57	Example 58
HFO-1132(E)	mass %	30.0	27.0	21.0	23.0	25.0	27.0	11.0	13.0
HFO-1123	mass %	52.0	42.0	46.0	44.0	42.0	40.0	54.0	52.0
R32	mass %	18.0	31.0	33.0	33.0	33.0	33.0	35.0	35.0
GWP	—	122	210	223	223	223	223	237	237
COP ratio	% (relative to R410A)	94.5	96.0	96.0	96.1	96.2	96.3	96.0	96.0
Refrigerating capacity ratio	% (relative to R410A)	112.1	113.7	114.3	114.2	114.0	113.8	115.0	114.9

TABLE 164

Item	Unit	Example 59	Example 60	Example 61	Example 62	Example 63	Example 64	Example 65	Example 66
HFO-1132(E)	mass %	15.0	17.0	19.0	21.0	23.0	25.0	27.0	11.0
HFO-1123	mass %	50.0	48.0	46.0	44.0	42.0	40.0	38.0	52.0
R32	mass %	35.0	35.0	35.0	35.0	35.0	35.0	35.0	37.0
GWP	—	237	237	237	237	237	237	237	250
COP ratio	% (relative to R410A)	96.1	96.2	96.2	96.3	96.4	96.4	96.5	96.2
Refrigerating capacity ratio	% (relative to R410A)	114.8	114.7	114.5	114.4	114.2	114.1	113.9	115.1

TABLE 165

Item	Unit	Example 67	Example 68	Example 69	Example 70	Example 71	Example 72	Example 73	Example 74
HFO-1132(E)	mass %	13.0	15.0	17.0	15.0	17.0	19.0	21.0	23.0
HFO-1123	mass %	50.0	48.0	46.0	50.0	48.0	46.0	44.0	42.0
R32	mass %	37.0	37.0	37.0	0.0	0.0	0.0	0.0	0.0
GWP	—	250	250	250	237	237	237	237	237
COP ratio	% (relative to R410A)	96.3	96.4	96.4	96.1	96.2	96.2	96.3	96.4
Refrigerating capacity ratio	% (relative to R410A)	115.0	114.9	114.7	114.8	114.7	114.5	114.4	114.2

TABLE 166

Item	Unit	Example 75	Example 76	Example 77	Example 78	Example 79	Example 80	Example 81	Example 82
HFO-1132(E)	mass %	25.0	27.0	11.0	19.0	21.0	23.0	25.0	27.0
HFO-1123	mass %	40.0	38.0	52.0	44.0	42.0	40.0	38.0	36.0
R32	mass %	0.0	0.0	0.0	37.0	37.0	37.0	37.0	37.0
GWP	—	237	237	250	250	250	250	250	250
COP ratio	% (relative to R410A)	96.4	96.5	96.2	96.5	96.5	96.6	96.7	96.8
Refrigerating capacity ratio	% (relative to R410A)	114.1	113.9	115.1	114.6	114.5	114.3	114.1	114.0

[0859] The above results indicate that under the condition that the mass % of HFO-1132(E), HFO-1123, and R32 based on their sum is respectively represented by x, y, and z, when coordinates (x,y,z) in a ternary composition diagram in which the sum of HFO-1132(E), HFO-1123, and R32 is 100 mass %, a line segment connecting a point (0.0, 100.0, 0.0) and a point (0.0, 0.0, 100.0) is the base, and the point (0.0, 100.0, 0.0) is on the left side are within the range of a figure surrounded by line segments that connect the following 4 points:

- point O (100.0, 0.0, 0.0),
- point A" (63.0, 0.0, 37.0),
- point B" (0.0, 63.0, 37.0), and
- point (0.0, 100.0, 0.0),

or on these line segments, the refrigerant has a GWP of 250 or less.

[0860] The results also indicate that when coordinates (x,y,z) are within the range of a figure surrounded by line segments that connect the following 4 points:

- point O (100.0, 0.0, 0.0),
- point A' (81.6, 0.0, 18.4),
- point B' (0.0, 81.6, 18.4), and
- point (0.0, 100.0, 0.0),

or on these line segments, the refrigerant has a GWP of 125 or less.

[0861] The results also indicate that when coordinates (x,y,z) are within the range of a figure surrounded by line segments that connect the following 4 points:

- point O (100.0, 0.0, 0.0),
- point A (90.5, 0.0, 9.5),
- point B (0.0, 90.5, 9.5), and
- point (0.0, 100.0, 0.0),

or on these line segments, the refrigerant has a GWP of 65 or less.

[0862] The results also indicate that when coordinates (x,y,z) are on the left side of line segments that connect the following 3 points:

point C (50.0, 31.6, 18.4),
 point U (28.7, 41.2, 30.1), and
 point D (52.2, 38.3, 9.5),
 or on these line segments, the refrigerant has a COP ratio of 96% or more relative to that of R410A.

[0863] In the above, the line segment CU is represented by coordinates $(-0.0538z^2+0.7888z+53.701, 0.0538z^2-1.7888z+46.299, z)$, and the line segment UD is represented by coordinates $(-3.4962z^2+210.71z-3146.1, 3.4962z^2-211.71z+3246.1, z)$.

[0864] The points on the line segment CU are determined from three points, i.e., point C, Comparative Example 10, and point U, by using the least-square method.

[0865] The points on the line segment UD are determined from three points, i.e., point U, Example 2, and point D, by using the least-square method.

[0866] The results also indicate that when coordinates (x,y,z) are on the left side of line segments that connect the following 3 points:

- point E (55.2, 44.8, 0.0),
- point T (34.8, 51.0, 14.2), and
- point F (0.0, 76.7, 23.3),

or on these line segments, the refrigerant has a COP ratio of 94.5% or more relative to that of R410A.

[0867] In the above, the line segment ET is represented by coordinates $(-0.0547z^2-0.5327z+53.4, 0.0547z^2-0.4673z+46.6, z)$, and the line segment TF is represented by coordinates $(-0.0982z^2+0.9622z+40.931, 0.0982z^2-1.9622z+59.069, z)$.

[0868] The points on the line segment ET are determined from three points, i.e., point E, Example 2, and point T, by using the least-square method.

[0869] The points on the line segment TF are determined from three points, i.e., points T, S, and F, by using the least-square method.

[0870] The results also indicate that when coordinates (x,y,z) are on the left side of line segments that connect the following 3 points:

point G (0.0, 76.7, 23.3),

point R (21.0, 69.5, 9.5), and

point H (0.0, 85.9, 14.1),

or on these line segments,

the refrigerant has a COP ratio of 93% or more relative to that of R410A.

[0871] In the above, the line segment GR is represented by coordinates $(-0.0491z^2-1.1544z+38.5, 0.0491z^2+0.1544z+61.5, z)$, and the line segment RH is represented by coordinates

$(-0.3123z^2+4.234z+11.06, 0.3123z^2-5.234z+88.94, z)$.

[0872] The points on the line segment GR are determined from three points, i.e., point G, Example 5, and point R, by using the least-square method.

[0873] The points on the line segment RH are determined from three points, i.e., point R, Example 7, and point H, by using the least-square method.

[0874] In contrast, as shown in, for example, Comparative Examples 8, 9, 13, 15, 17, and 18, when R32 is not contained, the concentrations of HFO-1132(E) and HFO-1123, which have a double bond, become relatively high; this undesirably leads to deterioration, such as decomposition, or polymerization in the refrigerant compound. The embodiments of the present disclosure have been described, but it should be understood that configurations and details can be modified in various ways without departing from the spirit and scope of the present disclosure as defined in the claims.

REFERENCE SIGNS LIST

[0875] 1 air conditioner (refrigeration cycle apparatus)

[0876] 4 compressor

[0877] 5 outdoor heat exchanger (condenser, evaporator)

[0878] 6 expansion valve (decompressing unit)

[0879] 7 indoor heat exchanger (evaporator, condenser)

[0880] 10 refrigerant circuit

CITATION LIST

Patent Literature

[0881] [PTL 1] International Publication No. 2015/141678

1. A refrigerating oil for a refrigerant composition comprising a refrigerant,

wherein the refrigerant is any one of refrigerants below:

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and 2,3,3,3-tetrafluoro-1-propene (R1234yf);

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)) and trifluoroethylene (HFO-1123) in a total amount of 99.5 mass % or more relative to a whole amount of the refrigerant and comprising HFO-1132(E) in an amount of 62.0 mass % to 72.0 mass % relative to a whole amount of the refrigerant;

a refrigerant comprising HFO-1132(E) and HFO-1123 in a total amount of 99.5 mass % or more relative to a whole amount of the refrigerant and comprising HFO-1132(E) in an amount of 45.1 mass % to 47.1 mass % relative to a whole amount of the refrigerant;

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), 2,3,3,3-tetrafluoro-1-propene (R1234yf), and difluoromethane (R32), wherein when x, y, z, and a respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32, coordinates (x, y, z) are defined as follows in a ternary diagram in which a total content of the HFO-1132(E), the HFO-1123, and the R1234yf is (100-a) mass %:

when $0 < a \leq 11.1$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BD', D'C, and CG that each connect two of six points below or on the straight lines GI, AB, and D'C (except for on point G, point I, point A, point B, point D', and point C):

point G $(0.026a^2-1.7478a+72.0, -0.026a^2+0.7478a+28.0, 0.0)$,

point I $(0.026a^2-1.7478a+72.0, 0.0, -0.026a^2+0.7478a+28.0)$,

point A $(0.0134a^2-1.9681a+68.6, 0.0, -0.0134a^2+0.9681a+31.4)$,

point B $(0.0, 0.0144a^2-1.6377a+58.7, -0.0144a^2+0.6377a+41.3)$,

point D' $(0.0, 0.0224a^2+0.968a+75.4, -0.0224a^2-1.968a+24.6)$, and

point C $(-0.2304a^2-0.4062a+32.9, 0.2304a^2-0.5938a+67.1, 0.0)$,

when $11.1 < a \leq 18.2$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G $(0.02a^2-1.6013a+71.105, -0.02a^2+0.6013a+28.895, 0.0)$,

point I $(0.02a^2-1.6013a+71.105, 0.0, -0.02a^2+0.6013a+28.895)$,

point A $(0.0112a^2-1.9337a+68.484, 0.0, -0.0112a^2+0.9337a+31.516)$,

point B $(0.0, 0.0075a^2-1.5156a+58.199, -0.0075a^2+0.5156a+41.801)$, and

point W $(0.0, 100.0-a, 0.0)$,

when $18.2 < a \leq 26.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G $(0.0135a^2-1.4068a+69.727, -0.0135a^2+0.4068a+30.273, 0.0)$,

point I $(0.0135a^2-1.4068a+69.727, 0.0, -0.0135a^2+0.4068a+30.273)$,

point A $(0.0107a^2-1.9142a+68.305, 0.0, -0.0107a^2+0.9142a+31.695)$,

point B $(0.0, 0.009a^2-1.6045a+59.318, -0.009a^2+0.6045a+40.682)$, and

point W $(0.0, 100.0-a, 0.0)$,

when $26.7 < a \leq 36.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G $(0.0111a^2-1.3152a+68.986, -0.0111a^2+0.3152a+31.014, 0.0)$,

point I ($0.0111a^2-1.3152a+68.986$, 0.0 , $-0.0111a^2+0.3152a+31.014$),

point A ($0.0103a^2-1.9225a+68.793$, 0.0 , $-0.0103a^2+0.9225a+31.207$),

point B (0.0 , $0.0046a^2-1.41a+57.286$, $-0.0046a^2+0.41a+42.714$), and

point W (0.0 , $100.0-a$, 0.0), and

when $36.7 < a \leq 46.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G ($0.0061a^2-0.9918a+63.902$, $-0.0061a^2-0.0082a+36.098$, 0.0),

point I ($0.0061a^2-0.9918a+63.902$, 0.0 , $-0.0061a^2-0.0082a+36.098$),

point A ($0.0085a^2-1.8102a+67.1$, 0.0 , $-0.0085a^2+0.8102a+32.9$),

point B (0.0 , $0.0012a^2-1.1659a+52.95$, $-0.0012a^2+0.1659a+47.05$), and

point W (0.0 , $100.0-a$, 0.0);

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), 2,3,3,3-tetrafluoro-1-propene (R1234yf), and difluoromethane (R32), wherein when x, y, z, and a respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32, coordinates (x, y, z) are defined as follows in a ternary diagram in which a total content of the HFO-1132(E), the HFO-1123, and the R1234yf is (100-a) mass %:

when $0 < a \leq 11.1$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BD', D'C, and CJ that each connect two of five points below or on the straight lines JK', K'B, and D'C (except for on point J, point B, point D', and point C):

point J ($0.0049a^2-0.9645a+47.1$, $-0.0049a^2-0.0355a+52.9$, 0.0),

point K' ($0.0514a^2-2.4353a+61.7$, $-0.0323a^2+0.4122a+5.9$, $-0.0191a^2+1.0231a+32.4$),

point B (0.0 , $0.0144a^2-1.6377a+58.7$, $-0.0144a^2+0.6377a+41.3$),

point D' (0.0 , $0.0224a^2+0.968a+75.4$, $-0.0224a^2-1.968a+24.6$), and

point C ($-0.2304a^2-0.4062a+32.9$, $0.2304a^2-0.5938a+67.1$, 0.0),

when $11.1 < a \leq 18.2$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BW, and WJ that each connect two of four points below or on the straight lines JK' and K'B (except for on point J, point B, and point W):

point J ($0.0243a^2-1.4161a+49.725$, $-0.0243a^2+0.4161a+50.275$, 0.0),

point K' ($0.0341a^2-2.1977a+61.187$, $-0.0236a^2+0.34a+5.636$, $-0.0105a^2+0.8577a+33.177$),

point B (0.0 , $0.0075a^2-1.5156a+58.199$, $-0.0075a^2+0.5156a+41.801$), and

point W (0.0 , $100.0-a$, 0.0),

when $18.2 < a \leq 26.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BW, and WJ that each connect two of four points below or on the straight lines JK' and K'B (except for on point J, point B, and point W):

point J ($0.0246a^2-1.4476a+50.184$, $-0.0246a^2+0.4476a+49.816$, 0.0),

point K' ($0.0196a^2-1.7863a+58.515$, $-0.0079a^2-0.1136a+8.702$, $-0.0117a^2+0.8999a+32.783$),

point B (0.0 , $0.009a^2-1.6045a+59.318$, $-0.009a^2+0.6045a+40.682$), and

point W (0.0 , $100.0-a$, 0.0),

when $26.7 < a \leq 36.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'A, AB, BW, and WJ that each connect two of five points below or on the straight lines JK', K'A, and AB (except for on point J, point B, and point W):

point J ($0.0183a^2-1.1399a+46.493$, $-0.0183a^2+0.1399a+53.507$, 0.0),

point K' ($-0.0051a^2+0.0929a+25.95$, 0.0 , $0.0051a^2-1.0929a+74.05$),

point A ($0.0103a^2-1.9225a+68.793$, 0.0 , $-0.0103a^2+0.9225a+31.207$),

point B (0.0 , $0.0046a^2-1.41a+57.286$, $-0.0046a^2+0.41a+42.714$), and

point W (0.0 , $100.0-a$, 0.0), and

when $36.7 < a \leq 46.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'A, AB, BW, and WJ that each connect two of five points below or on the straight lines JK', K'A, and AB (except for on point J, point B, and point W):

point J ($-0.0134a^2+1.0956a+7.13$, $0.0134a^2-2.0956a+92.87$, 0.0),

point K' ($-1.892a+29.443$, 0.0 , $0.892a+70.557$),

point A ($0.0085a^2-1.8102a+67.1$, 0.0 , $-0.0085a^2+0.8102a+32.9$),

point B (0.0 , $0.0012a^2-1.1659a+52.95$, $-0.0012a^2+0.1659a+47.05$), and

point W (0.0 , $100.0-a$, 0.0);

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), difluoromethane (R32), and 2,3,3,3-tetrafluoro-1-propene (R1234yf), wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments IJ, JN, NE, and EI that each connect two of four points below or on the line segments (except for a point on the line segment EI) in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

point I (72.0, 0.0, 28.0),

point J (48.5, 18.3, 33.2),

point N (27.7, 18.2, 54.1), and

point E (58.3, 0.0, 41.7),

the line segment U is represented by coordinates ($0.0236y^2-1.7616y+72.0$, y , $-0.0236y^2+0.7616y+28.0$),

the line segment NE is represented by coordinates ($0.012y^2-1.9003y+58.3$, y , $-0.012y^2+0.9003y+41.7$), and

the line segments JN and EI are straight lines;

a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line

- segments MM', M'N, NV, VG; and GM that each connect two of five points below or on the line segments (except for a point on the line segment GM) in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:
- point M (52.6, 0.0, 47.4),
 point M' (39.2, 5.0, 55.8),
 point N (27.7, 18.2, 54.1),
 point V (11.0, 18.1, 70.9), and
 point G (39.6, 0.0, 60.4),
 the line segment MM' is represented by coordinates $(0.132y^2 - 3.34y + 52.6, y, -0.132y^2 + 2.34y + 47.4)$,
 the line segment M'N is represented by coordinates $(0.0596y^2 - 2.2541y + 48.98, y, -0.0596y^2 + 1.2541y + 51.02)$,
 the line segment VG is represented by coordinates $(0.0123y^2 - 1.8033y + 39.6, y, -0.0123y^2 + 0.8033y + 60.4)$, and
 the line segments NV and GM are straight lines;
 a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments ON, NU, and UO that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:
- point O (22.6, 36.8, 40.6),
 point N (27.7, 18.2, 54.1), and
 point U (3.9, 36.7, 59.4),
 the line segment ON is represented by coordinates $(0.0072y^2 - 0.6701y + 37.512, y, -0.0072y^2 - 0.3299y + 62.488)$,
 the line segment NU is represented by coordinates $(0.0083y^2 - 1.7403y + 56.635, y, -0.0083y^2 + 0.7403y + 43.365)$, and
 the line segment UO is a straight line;
 a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments QR, RT, TL, LK, and KQ that each connect two of five points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:
- point Q (44.6, 23.0, 32.4),
 point R (25.5, 36.8, 37.7),
 point T (8.6, 51.6, 39.8),
 point L (28.9, 51.7, 19.4), and
 point K (35.6, 36.8, 27.6),
 the line segment QR is represented by coordinates $(0.0099y^2 - 1.975y + 84.765, y, -0.0099y^2 + 0.975y + 15.235)$,
 the line segment RT is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$,
 the line segment LK is represented by coordinates $(0.0049y^2 - 0.8842y + 61.488, y, -0.0049y^2 - 0.1158y + 38.512)$,
 the line segment KQ is represented by coordinates $(0.0095y^2 - 1.2222y + 67.676, y, -0.0095y^2 + 0.2222y + 32.324)$, and
 the line segment TL is a straight line;
 a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments PS, ST, and TP that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:
- point P (20.5, 51.7, 27.8),
 point S (21.9, 39.7, 38.4), and
 point T (8.6, 51.6, 39.8),
 the line segment PS is represented by coordinates $(0.0064y^2 - 0.7103y + 40.1, y, -0.0064y^2 - 0.2897y + 59.9)$,
 the line segment ST is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$, and
 the line segment TP is a straight line;
 a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and difluoromethane (R32), wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments IK, KB', B'H, HR, RG, and GI that each connect two of six points below or on the line segments (except for points on the line segments B'H and GI) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:
- point I (72.0, 28.0, 0.0),
 point K (48.4, 33.2, 18.4),
 point B' (0.0, 81.6, 18.4),
 point H (0.0, 84.2, 15.8),
 point R (23.1, 67.4, 9.5), and
 point G (38.5, 61.5, 0.0),
 the line segment IK is represented by coordinates $(0.025z^2 - 1.7429z + 72.00, -0.025z^2 + 0.7429z + 28.0, z)$,
 the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$,
 the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and
 the line segments KB' and GI are straight lines;
 a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments U, JR, RG, and GI that each connect two of four points below or on the line segments (except for a point on the

line segment GI) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point I (72.0, 28.0, 0.0),

point J (57.7, 32.8, 9.5),

point R (23.1, 67.4, 9.5), and

point G (38.5, 61.5, 0.0),

the line segment IJ is represented by coordinates $(0.025z^2 - 1.7429z + 72.0, -0.025z^2 + 0.7429z + 28.0, z)$,

the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

the line segments JR and GI are straight lines;

a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments MP, PB', B'H, HR, RG, and GM that each connect two of six points below or on the line segments (except for points on the line segments B'H and GM) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point M (47.1, 52.9, 0.0),

point P (31.8, 49.8, 18.4),

point B' (0.0, 81.6, 18.4),

point H (0.0, 84.2, 15.8),

point R (23.1, 67.4, 9.5), and

point G (38.5, 61.5, 0.0),

the line segment MP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,

the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$,

the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

the line segments PB' and GM are straight lines;

a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments MN, NR, RG, and GM that each connect two of four points below or on the line segments (except for a point on the line segment GM) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point M (47.1, 52.9, 0.0),

point N (38.5, 52.1, 9.5),

point R (23.1, 67.4, 9.5), and

point G (38.5, 61.5, 0.0),

the line segment MN is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,

the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

the line segments JR and GI are straight lines;

a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z)

are located within a region surrounded by line segments PS, ST, and TP that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point P (31.8, 49.8, 18.4),

point S (25.4, 56.2, 18.4), and

point T (34.8, 51.0, 14.2),

the line segment ST is represented by coordinates $(-0.0982z^2 + 0.9622z + 40.931, 0.0982z^2 - 1.9622z + 59.069, z)$,

the line segment TP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$, and

the line segment PS is a straight line; and

a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments QB', B'D, DU, and UQ that each connect two of four points below or on the line segments (except for a point on the line segment B'D) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point Q (28.6, 34.4, 37.0),

point B' (0.0, 63.0, 37.0),

point D (0.0, 67.0, 33.0), and

point U (28.7, 41.2, 30.1),

the line segment DU is represented by coordinates $(-3.4962z^2 + 210.71z - 3146.1, 3.4962z^2 - 211.71z + 3246.1, z)$,

the line segment UQ is represented by coordinates $(0.0135z^2 - 0.9181z + 44.133, -0.0135z^2 - 0.0819z + 55.867, z)$, and

the line segments QB' and B'D are straight lines.

2. The refrigerating oil for a refrigerant composition according to claim 1,

wherein the refrigerating oil has a kinematic viscosity at 40° C. of 1 mm²/s or more and 750 mm²/s or less.

3. The refrigerating oil for a refrigerant composition according to claim 1,

wherein the refrigerating oil has a kinematic viscosity at 100° C. of 1 mm²/s or more and 100 mm²/s or less.

4. The refrigerating oil for a refrigerant composition according to claim 1,

wherein the refrigerating oil has a volume resistivity at 25° C. of 1.0×10^{12} Ω·cm or more.

5. The refrigerating oil for a refrigerant composition according to claim 1,

wherein the refrigerating oil has an acid number of 0.1 mgKOH/g or less.

6. The refrigerating oil for a refrigerant composition according to claim 1,

wherein the refrigerating oil has an ash content of 100 ppm or less.

7. The refrigerating oil for a refrigerant composition according to claim 1,

wherein the refrigerating oil has an aniline point of -100° C. or higher and 0° C. or lower.

8. A method for using a refrigerating oil together with a refrigerant composition comprising a refrigerant,

wherein the refrigerant is any one of refrigerants below:
a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and 2,3,3,3-tetrafluoro-1-propene (R1234yf);

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)) and trifluoroethylene (HFO-1123) in a total amount of 99.5 mass % or more relative to a whole amount of the refrigerant and comprising HFO-1132(E) in an amount of 62.0 mass % to 72.0 mass % relative to a whole amount of the refrigerant;

a refrigerant comprising HFO-1132(E) and HFO-1123 in a total amount of 99.5 mass % or more relative to a whole amount of the refrigerant and comprising HFO-1132(E) in an amount of 45.1 mass % to 47.1 mass % relative to a whole amount of the refrigerant;

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), 2,3,3,3-tetrafluoro-1-propene (R1234yf), and difluoromethane (R32), wherein when x, y, z, and a respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32, coordinates (x, y, z) are defined as follows in a ternary diagram in which a total content of the HFO-1132(E), the HFO-1123, and the R1234yf is (100-a) mass %:

when $0 < a \leq 11.1$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BD', D'C, and CG that each connect two of six points below or on the straight lines GI, AB, and D'C (except for on point G, point I, point A, point B, point D', and point C):

point G (0.026a²-1.7478a+72.0, -0.026a²+0.7478a+28.0, 0.0),

point I (0.026a²-1.7478a+72.0, 0.0, -0.026a²+0.7478a+28.0),

point A (0.0134a²-1.9681a+68.6, 0.0, -0.0134a²+0.9681a+31.4),

point B (0.0, 0.0144a²-1.6377a+58.7, -0.0144a²+0.6377a+41.3),

point D' (0.0, 0.0224a²+0.968a+75.4, -0.0224a²-1.968a+24.6), and

point C (-0.2304a²-0.4062a+32.9, 0.2304a²-0.5938a+67.1, 0.0),

when $11.1 < a \leq 18.2$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G (0.02a²-1.6013a+71.105, -0.02a²+0.6013a+28.895, 0.0),

point I (0.02a²-1.6013a+71.105, 0.0, -0.02a²+0.6013a+28.895),

point A (0.0112a²-1.9337a+68.484, 0.0, -0.0112a²+0.9337a+31.516),

point B (0.0, 0.0075a²-1.5156a+58.199, -0.0075a²+0.5156a+41.801), and

point W (0.0, 100.0-a, 0.0),

when $18.2 < a \leq 26.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points

below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G (0.0135a²-1.4068a+69.727, -0.0135a²+0.4068a+30.273, 0.0),

point I (0.0135a²-1.4068a+69.727, 0.0, -0.0135a²+0.4068a+30.273),

point A (0.0107a²-1.9142a+68.305, 0.0, -0.0107a²+0.9142a+31.695),

point B (0.0, 0.009a²-1.6045a+59.318, -0.009a²+0.6045a+40.682), and

point W (0.0, 100.0-a, 0.0),

when $26.7 < a \leq 36.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G (0.0111a²-1.3152a+68.986, -0.0111a²+0.3152a+31.014, 0.0),

point I (0.0111a²-1.3152a+68.986, 0.0, -0.0111a²+0.3152a+31.014),

point A (0.0103a²-1.9225a+68.793, 0.0, -0.0103a²+0.9225a+31.207),

point B (0.0, 0.0046a²-1.41a+57.286, -0.0046a²+0.41a+42.714), and

point W (0.0, 100.0-a, 0.0), and

when $36.7 < a \leq 46.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines GI, IA, AB, BW, and WG that each connect two of five points below or on the straight lines GI and AB (except for on point G, point I, point A, point B, and point W):

point G (0.0061a²-0.9918a+63.902, -0.0061a²-0.0082a+36.098, 0.0),

point I (0.0061a²-0.9918a+63.902, 0.0, -0.0061a²-0.0082a+36.098),

point A (0.0085a²-1.8102a+67.1, 0.0, -0.0085a²+0.8102a+32.9),

point B (0.0, 0.0012a²-1.1659a+52.95, -0.0012a²+0.1659a+47.05), and

point W (0.0, 100.0-a, 0.0);

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), 2,3,3,3-tetrafluoro-1-propene (R1234yf), and difluoromethane (R32), wherein when x, y, z, and a respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, the R1234yf, and the R32, coordinates (x, y, z) are defined as follows in a ternary diagram in which a total content of the HFO-1132(E), the HFO-1123, and the R1234yf is (100-a) mass %:

when $0 < a \leq 11.1$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BD', D'C, and CJ that each connect two of five points below or on the straight lines JK', K'B, and D'C (except for on point J, point B, point D', and point C):

point J (0.0049a²-0.9645a+47.1, -0.0049a²-0.0355a+52.9, 0.0),

point K' (0.0514a²-2.4353a+61.7, -0.0323a²+0.4122a+5.9, -0.0191a²+1.0231a+32.4),

point B (0.0, 0.0144a²-1.6377a+58.7, -0.0144a²+0.6377a+41.3),

point D' (0.0, 0.0224a²+0.968a+75.4, -0.0224a²-1.968a+24.6), and

point C $(-0.2304a^2-0.4062a+32.9, 0.2304a^2-0.5938a+67.1, 0.0)$,

when $11.1 < a \leq 18.2$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BW, and WJ that each connect two of four points below or on the straight lines JK' and KB (except for on point J, point B, and point W):

point J $(0.0243a^2-1.4161a+49.725, -0.0243a^2+0.4161a+50.275, 0.0)$,

point K' $(0.0341a^2-2.1977a+61.187, -0.0236a^2+0.34a+5.636, -0.0105a^2+0.8577a+33.177)$,

point B $(0.0, 0.0075a^2-1.5156a+58.199, -0.0075a^2+0.5156a+41.801)$, and

point W $(0.0, 100.0-a, 0.0)$,

when $18.2 < a \leq 26.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'B, BW, and WJ that each connect two of four points below or on the straight lines JK' and K'B (except for on point J, point B, and point W):

point J $(0.0246a^2-1.4476a+50.184, -0.0246a^2+0.4476a+49.816, 0.0)$,

point K' $(0.0196a^2-1.7863a+58.515, -0.0079a^2-0.1136a+8.702, -0.0117a^2+0.8999a+32.783)$,

point B $(0.0, 0.009a^2-1.6045a+59.318, -0.009a^2+0.6045a+40.682)$, and

point W $(0.0, 100.0-a, 0.0)$,

when $26.7 < a \leq 36.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'A, AB, BW, and WJ that each connect two of five points below or on the straight lines JK', K'A, and AB (except for on point J, point B, and point W):

point J $(0.0183a^2-1.1399a+46.493, -0.0183a^2+0.1399a+53.507, 0.0)$,

point K' $(-0.0051a^2+0.0929a+25.95, 0.0, 0.0051a^2-1.0929a+74.05)$,

point A $(0.0103a^2-1.9225a+68.793, 0.0, -0.0103a^2+0.9225a+31.207)$,

point B $(0.0, 0.0046a^2-1.41a+57.286, -0.0046a^2+0.41a+42.714)$, and

point W $(0.0, 100.0-a, 0.0)$, and

when $36.7 < a \leq 46.7$, the coordinates (x, y, z) are located within a region surrounded by straight lines JK', K'A, AB, BW, and WJ that each connect two of five points below or on the straight lines JK', K'A, and AB (except for on point J, point B, and point W):

point J $(-0.0134a^2+1.0956a+7.13, 0.0134a^2-2.0956a+92.87, 0.0)$,

point K' $(-1.892a+29.443, 0.0, 0.892a+70.557)$,

point A $(0.0085a^2-1.8102a+67.1, 0.0, -0.0085a^2+0.8102a+32.9)$,

point B $(0.0, 0.0012a^2-1.1659a+52.95, -0.0012a^2+0.1659a+47.05)$, and

point W $(0.0, 100.0-a, 0.0)$;

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), difluoromethane (R32), and 2,3,3,3-tetrafluoro-1-propene (R1234yf), wherein when x, y , and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments IJ, JN, NE, and EI that each connect two of four points below or on the line segments (except for a point on the line segment

EI) in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

point I $(72.0, 0.0, 28.0)$,

point J $(48.5, 18.3, 33.2)$,

point N $(27.7, 18.2, 54.1)$, and

point E $(58.3, 0.0, 41.7)$,

the line segment IJ is represented by coordinates $(0.0236y^2-1.7616y+72.0, y, -0.0236y^2+0.7616y+28.0)$,

the line segment NE is represented by coordinates $(0.012y^2-1.9003y+58.3, y, -0.012y^2+0.9003y+41.7)$, and

the line segments JN and EI are straight lines;

a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y , and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments MM', M'N, NV, VG; and GM that each connect two of five points below or on the line segments (except for a point on the line segment GM) in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

point M $(52.6, 0.0, 47.4)$,

point M' $(39.2, 5.0, 55.8)$,

point N $(27.7, 18.2, 54.1)$,

point V $(11.0, 18.1, 70.9)$, and

point G $(39.6, 0.0, 60.4)$,

the line segment MM' is represented by coordinates $(0.132y^2-3.34y+52.6, y, -0.132y^2+2.34y+47.4)$,

the line segment M'N is represented by coordinates $(0.0596y^2-2.2541y+48.98, y, -0.0596y^2+1.2541y+51.02)$,

the line segment VG is represented by coordinates $(0.0123y^2-1.8033y+39.6, y, -0.0123y^2+0.8033y+60.4)$, and

the line segments NV and GM are straight lines;

a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y , and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments ON, NU, and UO that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

point O $(22.6, 36.8, 40.6)$,

point N $(27.7, 18.2, 54.1)$, and

point U $(3.9, 36.7, 59.4)$,

the line segment ON is represented by coordinates $(0.0072y^2-0.6701y+37.512, y, -0.0072y^2-0.3299y+62.488)$,

the line segment NU is represented by coordinates $(0.0083y^2-1.7403y+56.635, y, -0.0083y^2+0.7403y+43.365)$, and

the line segment UO is a straight line;

a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y , and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the

HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments QR, RT, TL, LK, and KQ that each connect two of five points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

point Q (44.6, 23.0, 32.4),
point R (25.5, 36.8, 37.7),
point T (8.6, 51.6, 39.8),
point L (28.9, 51.7, 19.4), and
point K (35.6, 36.8, 27.6),

the line segment QR is represented by coordinates $(0.0099y^2 - 1.975y + 84.765, y, -0.0099y^2 + 0.975y + 15.235)$,

the line segment RT is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$,

the line segment LK is represented by coordinates $(0.0049y^2 - 0.8842y + 61.488, y, -0.0049y^2 - 0.1158y + 38.512)$,

the line segment KQ is represented by coordinates $(0.0095y^2 - 1.2222y + 67.676, y, -0.0095y^2 + 0.2222y + 32.324)$, and

the line segment TL is a straight line;

a refrigerant comprising HFO-1132(E), R32, and R1234yf, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the R32, and the R1234yf relative to a total content of the HFO-1132(E), the R32, and the R1234yf, coordinates (x, y, z) are located within a region surrounded by line segments PS, ST, and TP that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the R32, and the R1234yf is 100 mass %:

point P (20.5, 51.7, 27.8),
point S (21.9, 39.7, 38.4), and
point T (8.6, 51.6, 39.8),

the line segment PS is represented by coordinates $(0.0064y^2 - 0.7103y + 40.1, y, -0.0064y^2 - 0.2897y + 59.9)$,

the line segment ST is represented by coordinates $(0.0082y^2 - 1.8683y + 83.126, y, -0.0082y^2 + 0.8683y + 16.874)$, and

the line segment TP is a straight line;

a refrigerant comprising trans-1,2-difluoroethylene (HFO-1132(E)), trifluoroethylene (HFO-1123), and difluoromethane (R32), wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments IK, KB', B'H, HR, RG, and GI that each connect two of six points below or on the line segments (except for points on the line segments B'H and GI) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point I (72.0, 28.0, 0.0),
point K (48.4, 33.2, 18.4),
point B' (0.0, 81.6, 18.4),
point H (0.0, 84.2, 15.8),
point R (23.1, 67.4, 9.5), and
point G (38.5, 61.5, 0.0),

the line segment IK is represented by coordinates $(0.025z^2 - 1.7429z + 72.00, -0.025z^2 + 0.7429z + 28.0, z)$,
the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$,
the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

the line segments KB' and GI are straight lines;

a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments U, JR, RG, and GI that each connect two of four points below or on the line segments (except for a point on the line segment GI) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point I (72.0, 28.0, 0.0),
point J (57.7, 32.8, 9.5),
point R (23.1, 67.4, 9.5), and
point G (38.5, 61.5, 0.0),

the line segment IJ is represented by coordinates $(0.025z^2 - 1.7429z + 72.0, -0.025z^2 + 0.7429z + 28.0, z)$,

the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

the line segments JR and GI are straight lines;

a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments MP, PB', B'H, HR, RG, and GM that each connect two of six points below or on the line segments (except for points on the line segments B'H and GM) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point M (47.1, 52.9, 0.0),
point P (31.8, 49.8, 18.4),
point B' (0.0, 81.6, 18.4),
point H (0.0, 84.2, 15.8),
point R (23.1, 67.4, 9.5), and
point G (38.5, 61.5, 0.0),

the line segment MP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,

the line segment HR is represented by coordinates $(-0.3123z^2 + 4.234z + 11.06, 0.3123z^2 - 5.234z + 88.94, z)$

the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$, and

the line segments PB' and GM are straight lines;

a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132(E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments MN, NR, RG, and GM that each connect two of four points below or on the line segments (except for a point on the line segment GM) in a ternary diagram in which

the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point M (47.1, 52.9, 0.0),
 point N (38.5, 52.1, 9.5),
 point R (23.1, 67.4, 9.5), and
 point G (38.5, 61.5, 0.0),
 the line segment MN is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,
 the line segment RG is represented by coordinates $(-0.0491z^2 - 1.1544z + 38.5, 0.0491z^2 + 0.1544z + 61.5, z)$,
 and
 the line segments JR and GI are straight lines;
 a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132 (E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments PS, ST, and TP that each connect two of three points below or on the line segments in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point P (31.8, 49.8, 18.4),
 point S (25.4, 56.2, 18.4), and
 point T (34.8, 51.0, 14.2),
 the line segment ST is represented by coordinates $(-0.0982z^2 + 0.9622z + 40.931, 0.0982z^2 - 1.9622z + 59.069, z)$,
 the line segment TP is represented by coordinates $(0.0083z^2 - 0.984z + 47.1, -0.0083z^2 - 0.016z + 52.9, z)$,
 and
 the line segment PS is a straight line; and
 a refrigerant comprising HFO-1132(E), HFO-1123, and R32, wherein when x, y, and z respectively represent contents (mass %) of the HFO-1132(E), the HFO-1123, and the R32 relative to a total content of the HFO-1132 (E), the HFO-1123, and the R32, coordinates (x, y, z) are located within a region surrounded by line segments QB', B'D, DU, and UQ that each connect two of four points below or on the line segments (except for a point

on the line segment B'D) in a ternary diagram in which the total content of the HFO-1132(E), the HFO-1123, and the R32 is 100 mass %:

point Q (28.6, 34.4, 37.0),
 point B' (0.0, 63.0, 37.0),
 point D (0.0, 67.0, 33.0), and
 point U (28.7, 41.2, 30.1),
 the line segment DU is represented by coordinates $(-3.4962z^2 + 210.71z - 3146.1, 3.4962z^2 - 211.71z + 3246.1, z)$,
 the line segment UQ is represented by coordinates $(0.0135z^2 - 0.9181z + 44.133, -0.0135z^2 - 0.0819z + 55.867, z)$, and
 the line segments QB' and B'D are straight lines.

9. The method for using a refrigerating oil according to claim **8**,
 wherein the refrigerating oil has a kinematic viscosity at 40° C. of 1 mm²/s or more and 750 mm²/s or less.

10. The method for using a refrigerating oil according to claim **8**,
 wherein the refrigerating oil has a kinematic viscosity at 100° C. of 1 mm²/s or more and 100 mm²/s or less.

11. The method for using a refrigerating oil according to claim **8**,
 wherein the refrigerating oil has a volume resistivity at 25° C. of 1.0×10^{12} Ω·cm or more.

12. The method for using a refrigerating oil according to claim **8**,
 wherein the refrigerating oil has an acid number of 0.1 mgKOH/g or less.

13. The method for using a refrigerating oil according to claim **8**,
 wherein the refrigerating oil has an ash content of 100 ppm or less.

14. The method for using a refrigerating oil according to claim **8**,
 wherein the refrigerating oil has an aniline point of -100° C. or higher and 0° C. or lower.

15-21. (canceled)

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