as high as 3922, which is equal to or higher than that of $CHClF_2$ (R22), which is a chlorine-containing fluorinated hydrocarbon. There is thus a desire to develop, as alternative refrigerants for R404A, a refrigerant and refrigerant composition that have, for example, a non-flammability similar to that of R404A, a refrigerating capacity that can replace that of R404A, a ratio of refrigerating capacity to power consumed in a refrigeration cycle (coefficient of performance (COP)) that is equal or superior to that of R404A, and a lower GWP than that of R404A.

Citation List

Patent Literature

[0005]

PTL 1: JP2869038B

PTL 2: U.S. Patent No. 8,168,077

Summary

Technical Problem

[0006]

An object of the present discloure is to provide, as alternative refrigerants for the R404A that is currently widely used, a refrigerant and refrigerant composition that have, for example, a non-flammability similar to that of R404A, a refrigerating capacity that can replace that of R404A, a COP equal or superior to that of R404A, and a lower GWP than that of R404A. The definition of non-flammability in the present specification conforms to U.S. ASHRAE Standard 34-2013.

Solution to Problem

[0007]

The present inventors conducted extensive research to achieve the above object, and found that the above object can be achieved by a composition comprising a mixture containing fluorinated hydrocarbons, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within

a triangle having the following three points as vertices in a ternary composition diagram (Fig. 1) in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:

point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),

point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and

point G (R32/R125/R134a = 29.4/14.1/56.5 wt%).

[0008]

The present disclosure has been accomplished through further research based on the above findings.

[0009]

Specifically, the present disclosure provides the following composition and the like.

Item 1. A composition comprising a mixture containing fluorinated hydrocarbons, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:

point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),

point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and

point G (R32/R125/R134a = 29.4/14.1/56.5 wt%).

Item 2. A composition comprising a mixture containing fluorinated hydrocarbons, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:

point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),

point D (R32/R125/R134a = 31.4/11.5/57.1 wt%), and

point E (R32/R125/R134a = 30.2/14.4/55.4 wt%).

Item 3. A composition comprising a mixture containing fluorinated hydrocarbons, the composition ratio of the fluorinated

Item 19. A refrigerating device comprising the composition according to any one of Items 1 to 15.

[0009a] In one aspect, there is provided a composition comprising a mixture containing fluorinated hydrocarbons, the mixture comprising difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:
point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),
point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and
point G (R32/R125/R134a = 29.4/14.1/56.5 wt%),
wherein the mixture is an alternative refrigerant for R404A that is a mixed refrigerant, and
wherein the mixture has a COP of 100% or more relative to the COP of R404A.

[0009b] In another aspect, there is provided a composition comprising a mixture containing fluorinated hydrocarbons, the mixture comprising difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:
point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),
point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and

point G (R32/R125/R134a = 29.4/14.1/56.5 wt%),
wherein the composition ratio falls within the following ranges: R32 = 32.5 wt%±1wt%, R125 = 15.0 wt%±1wt%, and R134a = 52.5 wt%±2wt%.

[0009c] In another aspect, there is provided a composition comprising a mixture containing fluorinated hydrocarbons, the mixture comprising difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a region enclosed by the following three straight lines in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:
first straight line ($y = 0.9286x - 16.643$, $z = 100 - x - y$, $19 \leq x \leq 61$),
second straight line ($y = 0.3644x + 3.400$, $z = 100 - x - y$, $0 \leq x \leq 70.8$), and
third straight line ($y = -2.35x + 83.25$, $25 \leq x \leq 35$).

[0009d] In another aspect, there is provided the composition as defined above used for at least one member selected from the group consisting of refrigerators, freezers, water coolers, ice machines, refrigerating showcases, freezing showcases, freezing and refrigerating units, refrigerating devices for freezing and refrigerating warehouses, chillers (chilling units), turbo refrigerators, and screw refrigerators.

[0009e] In another aspect, there is provided a refrigeration method comprising the step of operating a refrigeration cycle using the composition as defined above.

[0009f] In another aspect, there is provided a method for operating a refrigerating device, comprising operating a refrigeration cycle using the composition as defined herein.

[0009g] In another aspect, there is provided a refrigerating device comprising the composition as defined above.

[0009h] In another aspect, there is provided a method for producing a composition, comprising the step of mixing difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) such that the composition ratio thereof is adjusted to fall within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of R32, R125, and R134a is 100 wt%:
point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),
point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and
point G (R32/R125/R134a = 29.4/14.1/56.5 wt%),
wherein the mixture obtained in the step comprising R32, R125, and R134a in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, and
wherein the mixture obtained in the step being an alternative refrigerant for R404A that is a mixed refrigerant.

Advantageous Effects of Invention

[0010]

The present disclosure makes it possible to obtain a composition comprising a mixture containing fluorinated hydrocarbons that has, for example, a non-flammability similar to that of R404A, a refrigerating capacity that can replace that of R404A, a COP equal or superior to that of R404A, and a lower GWP than that of R404A because the composition ratio of the mixture falls within a triangle having the following three points as vertices in a ternary composition diagram for R32, R125, and R134a indicated by the triangular coordinates of Fig. 1:
point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),

point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and
point G (R32/R125/R134a = 29.4/14.1/56.5 wt%).

Brief Description of Drawings

[0011]

Fig. 1 illustrates a ternary composition diagram for R32, R125, and R134a in which the compositions of mixtures of the present invention (in order from biggest to smallest triangular range, a triangle defined by points A, F, and G, a triangle defined by points A, D, and E, and a triangle defined by points A, B, and C) are shown.

Fig. 2 illustrates a ternary composition diagram for R32, R125, and R134a in which P: ASHRAE non-flammable border line, Q: ASHRAE flammable region, and R: ASHRAE non-flammable region are shown. The diagram also shows the relationship between the allowable range (including an allowable error) set for each refrigerant in the production of a mixed refrigerant and criteria for determining whether the mixed refrigerant is classified as a mixed refrigerant that is non-flammable according to ASHRAE or a mixed refrigerant that is flammable according to ASHRAE.

CLAIMS

[Claim 1]

A composition comprising a mixture containing fluorinated hydrocarbons, the mixture comprising difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:
point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),
point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and
point G (R32/R125/R134a = 29.4/14.1/56.5 wt%),
wherein the mixture is an alternative refrigerant for R404A that is a mixed refrigerant, and
wherein the mixture has a COP of 100% or more relative to the COP of R404A.

[Claim 2]

A composition comprising a mixture containing fluorinated hydrocarbons, the mixture comprising difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:
point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),
point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and
point G (R32/R125/R134a = 29.4/14.1/56.5 wt%),

wherein the composition ratio falls within the following ranges: R32 = 32.5 wt%±1wt%, R125 = 15.0 wt%±1wt%, and R134a = 52.5 wt%±2wt%.

[Claim 3]

A composition comprising a mixture containing fluorinated hydrocarbons, the mixture comprising difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, the composition ratio of the fluorinated hydrocarbons contained in the mixture falling within a region enclosed by the following three straight lines in a ternary composition diagram in which the sum of the concentrations of difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) is 100 wt%:

first straight line ($y = 0.9286x - 16.643$, $z = 100 - x - y$, $19 \leq x \leq 61$), second straight line ($y = 0.3644x + 3.400$, $z = 100 - x - y$, $0 \leq x \leq 70.8$), and
third straight line ($y = -2.35x + 83.25$, $25 \leq x \leq 35$).

[Claim 4]

The composition according to any one of claims 1 to 3, wherein the mixture further comprises at least one fluorinated hydrocarbon selected from the group consisting of HCFC-1122, HCFC-124, CFC-1113, and 3,3,3-trifluoropropyne.

[Claim 5]

The composition according to any one of claims 1 to 4, wherein the mixture further comprises at least one halogenated organic compound represented by formula (1): $C_mH_nX_p$, wherein each X independently represents a fluorine atom, a chlorine atom, or a bromine atom, m is 1 or 2, $2m + 2 \geq n + p$, and $p \geq 1$.

[Claim 6]

The composition according to any one of claims 1 to 5, wherein the mixture further comprises at least one organic compound represented by formula (2): $C_mH_nX_p$, wherein each X independently represents an atom that is not a halogen atom, m is 1 or 2, $2m + 2 \geq n + p$, and $p \geq 1$.

[Claim 7]

The composition according to any one of claims 1 to 6, wherein the mixture further comprises water.

[Claim 8]

The composition according to any one of claims 1 to 3,

wherein the mixture consists of R32, R125, and R134a.

[Claim 9]

The composition according to any one of claims 1 to 8, wherein the mixture has a GWP of 1500 or less, and the refrigerating capacity of the mixture is 94% or more relative to the refrigerating capacity of R404A.

[Claim 10]

The composition according to any one of claims 2 to 9, wherein the mixture is an alternative refrigerant for R404A that is a mixed refrigerant.

[Claim 11]

The composition according to any one of claims 1 to 10, comprising a refrigerant oil.

[Claim 12]

The composition according to claim 11, wherein the refrigerant oil comprises at least one polymer selected from the group consisting of polyalkylene glycol (PAG), polyol ester (POE), and polyvinyl ether (PVE).

[Claim 13]

The composition according to any one of claims 1 to 12, comprising at least one substance selected from the group consisting of tracers, compatibilizers, ultraviolet fluorescent dyes, stabilizers, and polymerization inhibitors.

[Claim 14]

The composition according to any one of claims 1 to 13, which is used for at least one member selected from the group consisting of refrigerators, freezers, water coolers, ice machines, refrigerating showcases, freezing showcases, freezing and refrigerating units, refrigerating devices for freezing and

refrigerating warehouses, chillers (chilling units), turbo refrigerators, and screw refrigerators.

[Claim 15]

A refrigeration method comprising the step of operating a refrigeration cycle using the composition according to any one of claims 1 to 14.

[Claim 16]

A method for operating a refrigerating device, comprising operating a refrigeration cycle using the composition according to any one of claims 1 to 14.

[Claim 17]

A refrigerating device comprising the composition according to any one of claims 1 to 14.

[Claim 18]

A method for producing a composition, comprising the step of mixing difluoromethane (R32), pentafluoroethane (R125), and 1,1,1,2-tetrafluoroethane (R134a) such that the composition ratio thereof is adjusted to fall within a triangle having the following three points as vertices in a ternary composition diagram in which the sum of the concentrations of R32, R125, and R134a is 100 wt%:

point A (R32/R125/R134a = 37.3/17.0/45.7 wt%),

point F (R32/R125/R134a = 30.7/10.9/58.4 wt%), and

point G (R32/R125/R134a = 29.4/14.1/56.5 wt%),

wherein the mixture obtained in the step comprising R32, R125, and R134a in amounts such that the sum of the concentrations thereof is 99.5 wt% or more, and

wherein the mixture obtained in the step being an alternative refrigerant for R404A that is a mixed refrigerant.