



(11) (21) (C) **2,086,474**  
(22) 1992/12/30  
(43) 1993/09/06  
(45) 2000/02/29

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(51) Int.Cl.<sup>5</sup> C09K 5/04  
(30) 1992/03/05 (4-48704) JP  
(54) **FRIGORIGENES FLUOROCARBONES MIXTES**  
(54) **MIXED FLUOROCARBON REFRIGERANTS**

(57) Chlorine and bromine-free fluorocarbon refrigerants embodying a refrigeration temperature of -30°C or less, the refrigerants comprising \*Freon 134a (CH<sub>2</sub>FCF<sub>3</sub>) R-811-97-2 and \*Freon 23 (CHF<sub>3</sub>) R-75-46-7.



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ABSTRACT OF THE DISCLOSURE

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Chlorine and bromine-free fluorocarbon refrigerants embodying a refrigeration temperature of  $-30^{\circ}\text{C}$  or less, the refrigerants comprising \*Freon 134a ( $\text{CH}_2\text{FCF}_3$ ) R-811-97-2 and \*Freon 23 ( $\text{CHF}_3$ ) R-75-46-7 .

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\*Trade mark

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## MIXED FLUOROCARBON REFRIGERANTS

## BACKGROUND OF THE INVENTION

## 1. Field of the Invention

5           The present invention relates to a fluorocarbon refrigerant used as a working fluid medium in a refrigerator and other refrigeration cycles. More particularly, the present invention relates to a so-called \*"Freon (Fron) substitute" containing no chlorine or bromine. The Freon substitute  
10 disclosed herein is a mixed refrigerant of fluorocarbons which is able to obtain a refrigeration temperature of  $-30^{\circ}\text{C}$  or less.

## 2. Description of Related Art

Hitherto, because of their excellent properties, chlorofluorocarbons (CFC) have been widely used as the working  
15 fluid medium in various refrigeration cycles such as, for example, a refrigerator. However, it was recently found that CFC can damage the ozone layer of the earth. Also, to preserve the environment of the earth, each country has established its own regulations and schedules of regulations to inhibit and/or  
20 control the use of specified Freons including CFC in accordance with the provisions of international conventions. In addition to the control of specified Freons, research and development for providing a Freon substitute which does not contain chlorine, i.e., the detrimental substance which causes ozone  
25 layer damage, are being carried out in a great many companies

and institutes. Moreover, as a result of recent studies, the ozone layer damage caused by the specified Freons was noted to be a very important and severe problem which must be promptly solved, and accordingly each country started to practice the established regulations earlier than scheduled.

10 On the other hand, Freon 502 (azeotropic mixture of  $\text{CHClF}_2$  and  $\text{C}_2\text{ClF}_5$ ) and Freon 13B1 ( $\text{CBrF}_3$ ) are known to obtain a refrigeration temperature of  $-30^\circ\text{C}$  or less. However, both of these Freons cannot be used or are listed high on the schedule of regulations, because they contain chlorine or bromine. A Freon substitute (HFC) having an evaporation temperature (boiling point) of  $-30^\circ\text{C}$  or less has not yet been developed.

#### SUMMARY OF THE INVENTION

20 In view of the above-described technical background, one feature of the embodiment of the present invention is to provide a novel refrigerant which does not contain chlorine or bromine, and also which can obtain a refrigeration temperature of  $-30^\circ\text{C}$  or less.

In accordance with an embodiment of the invention there is provided a mixed refrigerant, comprising: a mixture comprising 60 to 95% by weight 1,1,1,2-tetrafluoroethane, and 5 to 40% by weight trifluoromethane, the mixture further comprising isopentane, the isopentane being present in an amount of 1.4 to 50.7% by weight of the mixture, to obtain a refrigeration temperature of less than or equal to  $-51^\circ\text{C}$ .

30 In accordance with another embodiment of the present invention there is provided a mixed refrigerant, comprising: a mixture comprising 60 to 95% by weight 1,1,1,2-tetra-

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fluoroethane, and 5 to 40% by weight trifluoromethane, the mixture further comprising at least two additives selected from the group consisting of pentene, isopentane and ethylbenzene, the at least two additives being present in an amount effective to obtain a refrigeration temperature of least than or equal to  $-51^{\circ}\text{C}$ .

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careful and thorough studies concerning the combined use of two or more fluorocarbons which contain hydrogen, but are free from chlorine and bromine, to thereby obtain a Freon working fluid medium having a boiling point of  $-30^{\circ}\text{C}$  or less.

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## DETAILED DESCRIPTION OF THE INVENTION

The fluorocarbon refrigerant according to the present invention, as mentioned above, comprises two types of fluorocarbons or Freons. One Freon is Freon 134a having a boiling point of  $-26.3^{\circ}\text{C}$ , another Freon is Freon 23 having a boiling point of  $-82.0^{\circ}\text{C}$ , and a mixture of these Freons is a non-azeotropic mixture. It should be noted, however, that the non-azeotropic mixture of Freon 134a and Freon 23 can provide a boiling point (refrigeration temperature) of  $-30^{\circ}\text{C}$  or less. The term "refrigeration temperature" used herein means the temperature typically occurring in a refrigerator or other machine.

Surprisingly, although a detailed mechanism thereof has not yet been clarified, it was noted that the boiling point of  $-30^{\circ}\text{C}$  or less can always be obtained, even if Freon 134a is mixed with a very small quantity of Freon 23.

The fluorocarbon refrigerant according to the present invention contains preferably 60 to 95% by weight of Freon 134a and 5 to 40% by weight of Freon 23, when the boiling point of  $-40^{\circ}\text{C}$  or less should be obtained.

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As described above, Freon 134a is preferably used in a mixing ratio of 60 to 95% by weight of the refrigerant to obtain the boiling point of  $-40^{\circ}\text{C}$  or less. If its mixing ratio exceeds 95% by weight, namely, if an amount of Freon 23 is used which is less than 5% by weight, it becomes difficult to stably obtain a refrigeration temperature of  $-40^{\circ}\text{C}$  or less. And, if the mixing ratio of Freon 23 exceeds 40% by weight, namely, if an amount of Freon 134a is used which is less than 60% by weight, the discharging pressure of the refrigerator or compressor might increase excessively. To avoid problems due to increased pressure, it is necessary to use a specially designed compressor. Note, if it is desired to obtain a refrigeration temperature of  $-45^{\circ}\text{C}$  or less without excessive increase in pressure, it is preferred to combine  $80 \pm 5\%$  by weight of Freon 134a and  $20 \pm 5\%$  by weight of Freon 23. Preferably, the best results will be obtained when  $76 \pm 2\%$  by weight of Freon 134a is combined with  $24 \pm 2\%$  by weight of Freon 23.

The mixed fluorocarbon refrigerant of the present invention may contain at least one additive selected from the group consisting of saturated hydrocarbons, unsaturated hydrocarbons and aromatic hydrocarbons, to further reduce the refrigeration temperature and also to reduce rather than increase the discharge pressure.

The saturated hydrocarbons used herein as an additive are generally represented by the formula:  $\text{C}_n\text{H}_{2n+2}$ ; wherein  $n$

represents an integer, and typical examples thereof include methane, ethane, propane, butane, pentane and isopentane. Preferably, isopentane is used as the additive. Moreover, very good results will be obtained if a refrigerant additive of high molecular weight hydrocarbons, trade mark "SDG" commercially available from Daiei Yakuhin Kogyo Kabushiki Kaisha, is used herein.

The unsaturated hydrocarbons used herein are generally represented by the formula:  $C_nH_{2n}$ ; wherein n is as defined above, and typical examples thereof include ethylene, propylene, butylene and pentene. Preferably, pentene is used.

The aromatic hydrocarbons used herein include, for example, benzene, toluene and ethylbenzene.

It was found that these hydrocarbon additives can increase the mixability of Freon 134a and Freon 23, further reduce the boiling point of the resultant refrigerant, and also reduce the discharging temperature of the machine.

The hydrocarbon additives could be added to either one of or both the refrigerant mixture or a refrigerator oil. By adding these additives to the refrigerator oil, it becomes possible to prevent sludge formation because of a high solubility of the additives in the oil, and accordingly stable operation of the refrigerator can be attained for a long period of time. It was also found that recycling of the oil was improved.

\*Trade-mark

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The amount of additives, when added to a refrigerator oil, is preferably 1 to 30% and more preferably 3 to 30% by weight with regard to the amount of the oil. An amount less than 1% by weight is not enough to give an advantageous effect on the refrigerator oil, and also it does not cause a significant change in the refrigeration capacity of the refrigerator. Contrary to this, when the amount of the additives exceeds 30% by weight, both the compression rate and refrigeration capacity tend to be reduced.

The present invention will be further described with reference to working examples thereof. Note that Freon 134a and Freon 23 used herein each have the following physical properties, and as is apparent from these properties, the novel mixed refrigerant of the present invention is a mixture of two, entirely different fluorocarbons.

Table 1

Item	Freon 134a	Freon 23
chemical name	1,1,1,2-tetrafluoroethane	trifluoromethane
chemical formula	$\text{CH}_2\text{FCF}_3$	$\text{CHF}_3$
5 molecular weight	102.03	70.01
boiling point( $^{\circ}\text{C}$ )	-26.3	-82.03
freezing point( $^{\circ}\text{C}$ )	-101	-155.2
critical temperature ( $^{\circ}\text{C}$ )	102.0	25.9
critical pressure(kgf/cm <sup>2</sup> )	42.0	49.3
critical density (g/cm <sup>3</sup> )	0.50	0.525
density		
10 -saturated liquid at 25 $^{\circ}\text{C}$ (g/cm <sup>3</sup> )	1.206	0.670
-saturated vapor at 25 $^{\circ}\text{C}$ (g/l)	32	4.66
specific heat		
-atmospheric pressure vapor at 25 $^{\circ}\text{C}$ (cal/g $\cdot^{\circ}\text{C}$ )	0.20	0.176
15 latent heat of evaporation at boiling point (cal/g)	51.7	57.04
thermal conductivity		
-saturated liquid at 25 $^{\circ}\text{C}$ (Kcal./m $\cdot$ hr $\cdot^{\circ}\text{C}$ )	0.07	0.117
-atmospheric pressure vapor at 25 $^{\circ}\text{C}$ (Kcal./m $\cdot$ hr $\cdot^{\circ}\text{C}$ )	0.009	0.012
20 viscosity		
-saturated liquid at 25 $^{\circ}\text{C}$ (cP)	0.20	0.303
-atmospheric pressure vapor at 25 $^{\circ}\text{C}$ (cP)	0.012	0.015
dielectric constant		
-atmospheric pressure vapor at 25 $^{\circ}\text{C}$	1.02	(no data)

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Examples 1A, 1B, 1C, 1D, 1E, 1F, 1G and 1H:

A mixed fluorocarbon refrigerant was prepared by mixing Freon 134a and Freon 23 in different mixing ratios, based on % by weight. The mixed refrigerant was introduced and sealed in a refrigerator/compressor (product of Dunfoss, Model F-14L), and the refrigerator was operated in accordance with the conventional manner. The experiments were carried out with regard to the items described in the following table (Table 2) which also includes the results of the experiments. Note, in each example, the total weight of the refrigerant was 220g, and a refrigerator oil was added in the amount of 600cc.

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Table 2

Examples

items	1A	1B	1C	1D	1E	1F	1G	1H
mixing ratio of Freon 134a:Freon 23 (wt. %:wt. %)								
discharge pressure abs (kg/cm <sup>2</sup> )	33.250	25.033	22.533	19.585	17.033	13.783	14.283	13.783
intake pressure abs (Kg/cm <sup>2</sup> )	2.321	1.633	1.333	1.103	0.897	1.833	0.761	0.693
compression ratio	14.35	15.33	16.90	17.76	18.99	15.33	18.77	19.89
refrigeration temp. (°C)	-42.3	-50.5	-48.3	-49.5	-49.4	-50.5	-37.1	-34.0
room temp. (°C)	30	30	30	30	30	30	30	30
temp. of discharge pipe (°C)	95.5	70.9	86.9	62.3	58.9	53.7	67.0	54.8
temp. of intake pipe (°C)	42.0	39.5	38.6	37.5	37.1	38.6	18.7	17.9

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The results recorded in Table 2 indicate that a refrigeration temperature of less than  $-30^{\circ}\text{C}$  could be obtained in each mixing ratio. Since the discharge pressure may increase with a reduction in the amount of Freon 134a used in the mixed refrigerant, an amount of Freon 134a which is below 60% by weight should be avoided.

Examples 2A, 2B, 2C, 2D, 2E, 2F, 2G and 2H:

The procedure of Examples 1A to 1H was repeated except that Freon 134a and Freon 23 were mixed in different ratios and isopentane as an additive was added to the refrigerator oil as shown in Table 3. Note that the amount of the refrigerant is 220g and the amount of the refrigerator oil is 600cc. The results of experiments are summarized in the following table (Table 3).

Table 3

Examples

items	2A	2B	2C	2D	2E	2F	2G	2H
4 mixing ratio of Freon 134a:Freon 23 (wt. %:wt. %)	60:40	76:24	76:24	76:24	76:24	76:24	80:20	90:10
20 amount of isopentane(cc)	25	5	25	50	100	180	25	25
6 discharge pressure abs(kg/cm <sup>2</sup> )	22.783	21.033	19.283	15.283	15.033	14.853	14.783	12.533
8 intake pressure abs(Kg/cm <sup>2</sup> )	1.533	1.183	1.283	1.133	1.233	1.198	0.897	0.761
4 compression ratio	14.86	17.78	15.03	13.49	12.19	12.02	16.43	16.47
refrigeration temp. ( °C )	-55.1	-46.6	-53.5	-53.9	-50.0	-46.5	-54.4	-47.3
room temp. ( °C )	30	30	30	30	30	30	30	30
temp. of discharge pipe ( °C )	71.4	73.4	65.9	61.0	63.8	62.5	57.1	55.7
temp. of intake pipe ( °C )	38.1	38.2	37.4	35.4	34.4	32.5	34.9	33.3

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The results recorded in Table 3 indicate that as a result of the addition of isopentane, the refrigeration temperature was further reduced and at the same time, the discharge pressure was lowered, in comparison with the results of Examples 1A to 1E. It was proved that the elevation of the discharge pressure can be avoided by adding isopentane, even if Freon 23 is used in a relatively increased amount. In Examples 2E and 2F, the respective refrigerator oils were weakened because of a decrease in viscosity.

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Examples 3A, 3B, 3C, 3D and 3E:

The procedure of Examples 1A to 1D was repeated except that the mixed refrigerant used in each example was prepared by mixing Freon 134a and Freon 23 in different mixing ratios, based on % by weight, of 76:24 (Examples 3A and 3B), 95:5 (Example 3C) and 76:24 (Examples 3D and 3E), and that in each example, an additive was added to the refrigerator oil as listed below.

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Example No.	additive	amount (cc)	total weight of refrigerant (g)	total amount of refrigerator oil (cc)
3A	isopentane	50	220	600
3B	isopentane	50	227	600
3C	isopentane	50	220	600
3D	ethylbenzene*	50	227	600
3E	pentene**	50	227	600

\* an aromatic hydrocarbon

\*\* an unsaturated hydrocarbon

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Note that Examples 3A and 3B are intended to ascertain the results when the best mixing ratio of Freon 134a and Freon 23 is applied, Example 3C is intended to ascertain a lower limit of the amount of Freon 23, and Examples 3D and 3E are intended to ascertain the results when an aromatic hydrocarbon additive and an unsaturated hydrocarbon additive are added to the oil, respectively. The results of the experiments are summarized in the following table (Table 4).

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Table 4

		Examples				
items		3A	3B	3C	3D	3E
5	mixing ratio of Freon 134a:Freon 23 (wt. %:wt. %)	76:24	76:24	95:5	76:24	76:24
	additive (50cc)	iso-pentane	iso-pentane	iso-pentane	ethyl-benzene	pentene
	discharge pressure abs(kg/cm <sup>2</sup> )	15.283	15.033	10.033	16.533	14.285
10	intake pressure abs(Kg/cm <sup>2</sup> )	1.133	1.033	0.761	1.033	0.999
	compression ratio refrigeration temp.(°C)	13.49 -53.6	14.55 -54.8	13.184 -43.2	16.00 -50.9	14.30 -53.7
	room temp. (°C)	30	30	30	30	30
	temp. of discharge pipe (°C)	61.0	65.6	67.0	69.1	71.0
15	temp. of intake pipe (°C)	35.4	31.8	18.7	37.4	33.9

The results recorded in Table 4 indicate that in Examples 3A and 3B, a refrigeration temperature approaching -55 °C was obtained, while the discharge pressure was maintained at a low level. The results of Example 3C evidence that even if Freon 23 is used in a mixing ratio of only 5% by weight, a refrigeration temperature of -40°C can be obtained. Further, the results of Examples 3D and 3E evidence that similar results can be obtained when the aromatic hydrocarbons or unsaturated hydrocarbons are used as an additive to the refrigerator oil.

Examples 4A, 4B, 4C and 4D:

The procedure of Examples 1A to 1H was repeated except that the mixed refrigerant used in each example was prepared by mixing Freon 134a and Freon 23 in a mixing ratio, based on % by weight, of 76:24, and that in each example, a combination of additives was added to the refrigerator oil as listed below.

Example No.	additive	amount (cc)	total weight of refrigerant (g)	total amount of refrigerator oil (cc)
4A	A + B	15 + 15	227	600
4B	A + C	15 + 15	227	600
4C	B + C	15 + 15	227	600
4D	A + B + C	10 + 10 + 10	227	600

Notes: A represents isopentane.

B represents pentene.

C represents ethylbenzene.

The results of the experiments are summarized in the following table (Table 5).

Table 5

		Examples			
items		4A	4B	4C	4D
5	mixing ratio of Freon 134a:Freon 23 (wt. %:wt. %)	76:24	76:24	76:24	76:24
	additive (30cc)	A+B	A+C	B+C	A+B+C
	discharge pressure abs(kg/cm <sup>2</sup> )	17.283	17.533	18.033	17.283
	intake pressure abs(Kg/cm <sup>2</sup> )	1.183	1.133	1.183	1.083
10	compression ratio	14.61	15.48	15.24	15.96
	refrigeration temp.(°C)	-54.5	-54.0	-51.9	-54.3
	room temp. (°C)	30	30	30	30
	temp. of discharge pipe(°C)	71.4	68.4	68.7	69.3
	temp. of intake pipe (°C)	36.6	37.2	37.8	36.4

The results recorded in Table 5 indicate that the refrigeration temperature of -51°C or less can be obtained by employing a combination of two or more additives.

As will be appreciated from the above descriptions, according to the present invention, a mixed fluorocarbon refrigerant which does not cause the problem of ozone layer damage, and which also reduces the temperature of a refrigerator to -30 °C or less can be obtained.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A mixed refrigerant, comprising:  
a mixture comprising 60 to 95% by weight 1,1,1,2-tetrafluoroethane, and 5 to 40% by weight trifluoromethane, said mixture further comprising isopentane, said isopentane being present in an amount of 1.4 to 50.7% by weight of the mixture, to obtain a refrigeration temperature of less than or equal to  $-51^{\circ}\text{C}$ .
2. The mixed refrigerant according to claim 1, comprising 75 to 85% by weight 1,1,1,2-tetrafluoroethane and 15 to 25% by weight trifluoromethane.
3. The mixed refrigerant according to claim 2, wherein said isopentane is present in an amount of at least about 7 percent by weight of said mixture.
4. The mixed refrigerant according to claim 3, wherein said isopentane is present in amount of at least about 14 percent by weight of said mixture.
5. The mixed refrigerant according to claim 1, further comprising at least one additive selected from the group consisting of pentene and ethylbenzene.
6. The mixed refrigerant according to claim 1, further comprising a refrigerator oil.
7. The mixed refrigerant according to claim 6, wherein said isopentane is present in an amount of 1 to 30% by weight of the refrigerator oil.
8. A mixed refrigerant, comprising:  
a mixture comprising 60 to 95% by weight 1,1,1,2-tetrafluoroethane, and 5 to 40% by weight trifluoromethane, said mixture further comprising at least two additives selected from the group consisting of pentene, isopentane and ethylbenzene, said at least two additives being present in an amount effective to obtain a refrigeration temperature of less than or equal to  $-51^{\circ}\text{C}$ .
9. The mixed refrigerant according to claim 8,

comprising 75 to 85% by weight 1,1,1,2-tetrafluoroethane and 15 to 25% by weight trifluoromethane.

10. The mixed refrigerant according to claim 8, further comprising a refrigerator oil.

11. A method of refrigeration comprising adding a mixed refrigerant to a refrigerator, wherein said mixed refrigerant comprises 60 to 95% by weight 1,1,1,2-tetrafluoroethane, 5 to 40% by weight trifluoromethane, and isopentane, said isopentane being present in an amount of 1.4 to 50.7% by weight of the mixture to obtain a refrigeration temperature of less than or equal to  $-51^{\circ}\text{C}$ .

12. The method of refrigeration according to claim 11, wherein said mixed refrigerant comprises 75 to 85% by weight 1,1,1,2-tetrafluoroethane and 15 to 25% by weight trifluoromethane.

13. The method of refrigeration according to claim 11, further comprising adding refrigerator oil to the mixed refrigerant.

14. The method of refrigeration according to claim 11, further comprising adding to said mixed refrigerant at least one additive selected from the group consisting of pentene and ethylbenzene.

15. A method of refrigeration comprising adding a mixed refrigerant to a refrigerator, wherein said mixed refrigerant comprises 60 to 95% by weight 1,1,1,2-tetrafluoroethane, 5 to 40% by weight trifluoromethane, and at least two additives selected from the group consisting of pentene, isopentane and ethylbenzene, said at least two additives being present in an amount effective to obtain a refrigeration temperature of less than or equal to  $-51^{\circ}\text{C}$ .

16. The method of refrigeration according to claim 15, wherein said mixed refrigerant comprises 75 to 85% by weight 1,1,1,2-tetrafluoroethane and 15 to 25% by weight trifluoromethane.

17. The method of refrigeration according to claim 15,

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further comprising adding refrigerant oil to the mixed refrigerant.