Title: LESS FLAMMABLE HYDROCARBON REFRIGERANT AS CFC-12 SUBSTITUTE

Abstract: The recent invention is a product that can be used as a refrigerant, as well as blowing agent, for CFC-12 and HFC-134a refrigerants replacement. The product is environmental friendly, less flammable, non-toxic, and non-corrosive. The refrigerant consists of 0 to 80% mass fraction of hydrocarbons and 20 to 70% mass fraction of non-flammable additive (low flammability suppressant substance). The application of the refrigerant in the refrigeration system improves the system performance, and needs less refrigerant charge.
LESS FLAMMABLE HYDROCARBON REFRIGERANT
AS CFC-12 SUBSTITUTE

Technical Field
The recent invention is a product, which is used as a working fluid (refrigerant) for a vapor compression refrigeration machine. The product can be used as a replacement for CFC-12, HFC-134a, or equivalent refrigerants. The product can also be used for other purposes such as propellant, blowing agent or solvent.

Background Art
Since it was found in 1930, chlorofluorocarbon (CFC) fluids have been used widely in engineering as refrigerants, blowing agents and solvents. The CFC advantages such as good thermodynamic property, non-flammable, non-corrosive, stable and harmless to the equipment material have made the CFCs consumption increases sharply since then. Later on, in year 1974 it was found that the presence of CFCs in the upper atmosphere depletes the ozone layer and increases the green house effect that cause global warming. This raise big problems in refrigeration engineering, since the international communities through the Montreal Protocol and its amendments have banned gradually the production and use of CFC.

Indonesian government through Presidential Decree No. 23/1992 and other related government regulations have banned the CFC import since January 1998.

HFC fluids have been introduced later on for CFCs replacement. However, the HFC fluids are not drop in substitutes, therefore it is not suitable for existing system that was designed to work with CFC refrigerant. Although HFC has zero Ozone Depleting Potential (ODP), it has high Global Warming Potential (GWP). Consequently, in climate change conventions HFC is considered as a high priority watched substance and its production might be strictly controlled in the future.

Indonesia is not CFC producer and considered as an Article 5 country (low CFC consumption country). However, the consumption of CFC for many purposes tends to increase and Indonesian industry strongly depends on it. Hence, the banned of CFC import has raised big problem for the Indonesian refrigeration
industries especially in year 2003 when the CFC stock is no longer available. Since the application of HFC-134a is costly and the application of hydrocarbon refrigerant in Indonesia and several other countries have shown good results, then the use of hydrocarbon-based refrigerant in Indonesia significantly increases.

The advantages of hydrocarbon refrigerants compared to other alternative refrigerants are:

a. Harmless to ozone layer (zero ODP).
b. Drop in CFC-substitute.
c. Both raw material and production technology are available in Indonesia.
d. Low global warming potential.
e. Increase the refrigeration system performance.

Disclosure of the Invention

The invention is a refrigerant (i.e. working fluid of refrigeration machine) for vapor compression refrigeration system, which can also be used as a blowing agent that equivalent to CFC-12 and HFC-134a. It is made of 0-80% mass fraction of hydrocarbon and 20-70% volatile non-flammable additive.

The additive substance mentioned above is non-flammable, non-corrosive, and non-toxic substance. It has normal boiling point range (at 1 bar absolute) between -45 to 35°C.

The refrigerants are zeotrope (non-azeotrope) mixtures of two or more components.

The refrigerants consist of (in mass fraction):

1. 0 to 50% of iso-butane (i-C₄H₁₀).
2. 0 to 40% of normal butane (n-C₄H₁₀).
3. Less than 30% of propane.
4. 20 to 70% of Low Flammability Suppressant (LFS).
5. Less than 1% of ethane or lighter hydrocarbon.
6. Less than 1% of pentane and iso-pentane or heavier hydrocarbon.

The composition of mixture stated above has to be adjusted so that its saturation pressure in the operating temperature range of the system is equivalent to the saturation pressure of CFC-12 (within 5% deviation).
The LFS used in the mixture is non-toxic, non-flammable (fire extinguisher), and non-corrosive, but volatile. With those properties of LFS, and if the composition is correct, then one would obtain a refrigerant with the following advantages:

1. Less flammable.
2. Non-toxic.
3. Non-corrosive and harmless to refrigeration system components.
4. Lower ODP and GWP compared to HCFC.
5. Drop in substitute to the CFC-12, HFC-134a, hydrocarbon, or any other equivalent refrigerant system.
6. Improve the refrigeration system performance (COP increases by 10 to 20% compared to that of CFC-12 or HFC-134a).
7. Less refrigerant charge (50 to 60% less) compared to that of CFC-12 or HFC-134a.
1. Refrigerant of vapor compression refrigeration machine with saturation pressure equivalent to that of CFC-12. HFC-134a or other equivalent refrigerant contains 0-80% mass fraction of hydrocarbon and 20-70% mass fraction of non flammable additive (low flammability suppressant substance).

2. The hydrocarbon in claim 1 consists of ethane (C₂H₆), propane (C₃H₈), normal butane (n-C₄H₁₀), iso-butane (i-C₄H₁₀), normal- and iso-pentane (C₅H₁₂).

3. The composition ranges (in mass fraction) of hydrocarbon mixture in claim 2 are
   - 0 to 50% of iso-butane (i-C₄H₁₀).
   - 0 to 40% of normal butane (n-C₄H₁₀).
   - Less than 30% of propane.
   - 20 to 70% of Low Flammability Suppressant (LFS).
   - Less than 1 % of ethane or lighter hydrocarbon.
   - Less than 1 % of pentane and iso-pentane or heavier hydrocarbon.

4. The additive component in claim 1 is a volatile, non-flammable, non toxic, and non-corrosive substance that has normal boiling point range (at 1 bar absolute) between -45 to 35°C.

5. The additive, as stated in claim 1, which has concentration range between 20 to 70% mass fraction. and has physical properties as stated in claim 4, is a pure or mixture substance.

6. The composition of mixture as stated in claim 3 and claim 4 is adjusted so that the saturation pressure at its operating temperature is equivalent to the saturation pressure of CFC-12 with deviation less than 5%.