

Description

This invention relates to azeotrope-like mixtures of 1,1-dichloro-1-fluoroethane, methanol and nitromethane. These mixtures are useful in a variety of vapor degreasing, cold cleaning and solvent cleaning applications including defluxing.

Vapor degreasing and solvent cleaning with fluorocarbon based solvents have found widespread use in industry for the degreasing and otherwise cleaning of solid surfaces, especially intricate parts and difficult to remove soils.

In its simplest form, vapor degreasing or solvent cleaning consists of exposing a room temperature object to be cleaned to the vapors of a boiling solvent. Vapors condensing on the object provide clean distilled solvent to wash away grease or other contamination. Final evaporation of solvent from the object leaves behind no residue as would be the case where the object is simply washed in liquid solvent.

For difficult to remove soils where elevated temperature is necessary to improve the cleaning action of the solvent, or for large volume assembly line operations where the cleaning of metal parts and assemblies must be done efficiently and quickly, the conventional operation of a vapor degreaser consists of immersing the part to be cleaned in a sump of boiling solvent which removes the bulk of the soil, thereafter immersing the part in a sump containing freshly distilled solvent near room temperature, and finally exposing the part to solvent vapors over the boiling sump which condense on the cleaned part. In addition, the part can also be sprayed with distilled solvent before final rinsing.

Vapor degreasers suitable in the above-described operations are well known in the art. For example, US-A-3085918 discloses such suitable vapor degreasers comprising a boiling sump, a clean sump, a water separator, and other ancillary equipment.

Cold cleaning is another application where a number of solvents are used. In most cold cleaning applications the soiled part is either immersed in the fluid or wiped with rags or similar objects soaked in solvents and allowed to air dry.

Fluorocarbon solvents, such as trichlorotrifluoroethane, have attained widespread use in recent years as effective, nontoxic, and nonflammable agents useful in degreasing applications and other solvent cleaning applications. Trichlorotrifluoroethane has been found to have satisfactory solvent power for greases, oils, waxes and the like. It has therefore found widespread use for cleaning electric motors, compressors, heavy metal parts, delicate precision metal parts, printed circuit boards, gyroscopes, guidance systems, aerospace and missile hardware, aluminum parts and the like.

The art has looked towards azeotropic compositions including the desired fluorocarbon components such as trichlorotrifluoroethane which include components which contribute additionally desired characteristics, such as polar functionality, increased solvency power, and stabilizers. Azeotropic compositions are desired because they exhibit a minimum or maximum boiling point and do not fractionate upon boiling. This behavior is desirable because in the previously described vapor degreasing equipment with which these solvents are employed, redistilled material is generated for final rinse-cleaning. Thus, the vapor degreasing system acts as a still. Unless the solvent composition exhibits a constant boiling point, i.e., is an azeotrope or is azeotrope-like, fractionation will occur and undesirable solvent distribution may act to upset the cleaning and safety of processing. Preferential evaporation of the more volatile components of the solvent mixtures, which would be the case if they were not an azeotrope or azeotrope-like, would result in mixtures with changed compositions which may have less desirable properties, such as lower solvency towards soils, less inertness towards metal, plastic or elastomer components, and increased flammability and toxicity.

The art is continually seeking new fluorocarbon based azeotropic mixtures or azeotrope-like mixtures which offer alternatives for new and special applications for vapor degreasing and other cleaning applications. Currently, of particular interest, are such azeotrope-like mixtures which are based on fluorocarbons which are considered to be stratospherically safe substitutes for presently used fully halogenated chlorofluorocarbons. The latter are suspected of causing environmental problems in connection with the earth's protective ozone layer. Mathematical models have substantiated that hydrochlorofluorocarbons, such as 1,1-dichloro-1-fluoroethane (FC-141b), will not adversely affect atmospheric chemistry, being negligible contributors to ozone depletion and to green-house global warming in comparison to the fully halogenated species.

One disclosure of an azeotropic composition including 1,1-dichloro-1-fluoroethane, is in Anon., Research Disclosures, Vol. 162, p. 70 (1977) in which it is stated that n-pentane and isopentane form binary azeotropes with 1,1-dichloro-1-fluoroethane.

US-A-3936387 discloses the azeotropic composition of methanol with 1,2-dichloro-1-fluoroethane, FC-141, which is an isomer of FC-141b. Similarly, US-A-4035258 discloses the azeotropic composition of ethanol with 1,2-dichloro-1-fluoroethane. This information did not lead us to the azeotropic composition of

the invention since, as is well known in this art, there is no published, reliable basis on which to predict azeotropy. Moreover, as is equally well known, the existence of an azeotropic composition does not enable one skilled in the art to predict azeotropy between or among related components. For example US-A-3936387 discloses that FC-141 and isopropanol form an azeotropic composition, whereas FC-141b and isopropanol do not form an azeotrope.

Nitromethane is a known stabilizer for preventing metal attack by chlorofluorocarbon mixtures containing alcohols. For example, US-A-3573213 discloses an azeotropic mixture of 1,1,2-trichloro-1,2,2-trifluoroethane with nitromethane in which mixture nitromethane is stated to perform such stabilizing function.

EP-A-0325265, which falls within the state of the art according to Article 54(3) EPC, discloses azeotrope or azeotrope-like compositions containing FC-141b with methanol or ethanol, which are stated to be useful in solvent cleaning applications.

It is accordingly an objection of this invention to provide novel azeotrope-like compositions based on FC-141b which are liquid at room temperature and which will not fractionate under the process of distillation or evaporation, which are useful as solvents for use in vapor degreasing and other solvent cleaning applications including defluxing applications. Another objection of the invention is to provide novel environmentally acceptable solvents for use in the aforementioned applications.

The present invention provides azeotrope-like compositions having boiling points of $29.4 \pm 0.1^\circ\text{C}$ at about 765 mm Hg (102 KPa) and comprising 93 to 98 weight percent of 1,1-dichloro-1-fluoroethane, 2 to 7 weight percent of methanol and 0.01 to 0.1 weight percent of nitromethane.

In a preferred embodiment of the invention, the azeotrope-like compositions comprise from 95.0 to 97.0 weight percent FC-141b, from 5 to 3 weight percent methanol, and from 0.1 to 0.01 weight percent nitromethane.

Our best estimate of the true azeotrope and our most preferred embodiment is about 96.0 weight percent FC-141b, about 3.9 weight percent methanol and about 0.01 weight percent nitromethane, which exhibits a boiling point of $29.4^\circ\text{C} \pm 0.1^\circ\text{C}$ at 760 mm Hg (101kPa).

All compositions within the above-identified ranges, as well as certain compositions outside the indicated ranges, are azeotrope-like, as defined more particularly below.

The precise or true azeotrope composition has not been determined but has been ascertained to be within the indicated ranges. Regardless of where the true azeotrope lies, all compositions within the indicated ranges, as well as certain compositions outside the indicated ranges, are azeotrope-like, as defined more particularly below.

It has been found that these azeotrope-like compositions are on the whole nonflammable liquids, i.e. exhibit no flash point when tested by the Tag Open Cup test method - ASTM D 1310-86. The vapor phase, however, does exhibit a narrow range of flame limits (9.9-15.2 volume percent in air at ambient conditions).

From fundamental principles, the thermodynamic state of a fluid is defined by four variables: pressure, temperature, liquid composition and vapor composition, or P-T-X-Y, respectively. An azeotrope is a unique characteristic of a system of two or more components where X and Y are equal at the stated P and T. In practice, this means that the components of a mixture cannot be separated during distillation, and therefore in vapor phase solvent cleaning as described above.

For the purpose of this discussion, by azeotrope-like composition is intended to mean that the composition behaves like a true azeotrope in terms of its constant boiling characteristics or tendency not to fractionate upon boiling or evaporation. Such composition may or may not be a true azeotrope. Thus, in such compositions, the composition of the vapor formed during boiling or evaporation is identical or substantially identical to the original liquid composition. Hence, during boiling or evaporation, the liquid composition, if it changes at all, changes only to a minimal or negligible extent. This is to be contrasted with non-azeotrope-like compositions in which during boiling or evaporation, the liquid composition changes to a substantial degree.

Thus, one way to determine whether a candidate mixture is "azeotrope-like" within the meaning of this invention, is to distill a sample thereof under conditions (i.e. resolution - number of plates) which would be expected to separate the mixture into its separate components. If the mixture is non-azeotropic or non-azeotrope-like, the mixture will fractionate, i.e. separate into its various components with the lowest boiling component distilling off first, and so on. If the mixture is azeotrope-like, some finite amount of a first distillation cut will be obtained which contains all of the mixture components and which is constant boiling or behaves as a single substance. This phenomenon cannot occur if the mixture is not azeotrope-like, i.e., it is not part of an azeotropic system. If the degree of fractionation of the candidate mixture is unduly great, then a composition closer to the true azeotrope must be selected to minimize fractionation. Of course, upon distillation of an azeotrope-like composition such as in a vapor degreaser, the true azeotrope will form and tend to concentrate.

It follows from the above that another characteristic of azeotrope-like compositions is that there is a range of compositions containing the same components in varying proportions which are azeotrope-like. All such compositions are intended to be covered by the term azeotrope-like as used herein. As an example, it is well known that at differing pressures, the composition of a given azeotrope will vary at least slightly as does the boiling point of the composition. Thus, an azeotrope of A and B represents a unique type of relationship but with a variable composition depending on temperature and/or pressure. Accordingly, another way of defining azeotrope-like within the meaning of this invention is to state that such mixtures of FC-141b, methanol and nitromethane boil within about $\pm 0.1^\circ\text{C}$ (at about 765 mm Hg) (102kPa) of the 29.4°C boiling point of the most preferred composition disclosed herein. As is readily understood by persons skilled in the art, the boiling point of the azeotrope will vary with the pressure.

In the process embodiment of the invention, the azeotrope-like compositions of the invention may be used to clean solid surfaces by treating said surfaces with said compositions in any manner well known to the art such as by dipping or spraying or use of conventional degreasing apparatus.

The FC-141b, methanol and nitromethane components of the novel solvent azeotrope-like compositions of the invention are known materials. Preferably, they should be used in sufficiently high purity so as to avoid the introduction of adverse influences upon the solvency properties or constant boiling properties of the system.

EXAMPLE

This example confirms the existence of the azeotrope between 1,1-dichloro-1-fluoroethane, methanol and nitromethane.

A 5-plate Oldershaw distillation column with a cold water condensed automatic liquid dividing head was used for this example. The distillation column was charged with a three component blend consisting of 3.8 weight percent methanol, 96.0 weight percent 1,1-dichloro-1-fluoroethane and 0.2 weight percent nitromethane which was heated under total reflux for about an hour to ensure equilibration. A reflux ratio of 5:1 was employed. Approximately 40 percent of the original charge was collected in five similar-sized overhead fractions. The compositions of these fractions, in addition to the composition of the liquid residue, were analyzed using gas chromatography. The table shows that the compositions of the starting material, the five distillate fractions and the liquid residue are identical, within the uncertainty associated with determining the compositions, indicating that the mixture is an azeotrope.

TABLE

	Methanol	FC-141b	Nitromethane
Starting Material (wt. %)	3.8	96.0	0.2
Constant Boiling Fractions (wt. %)	3.9	96.0	0.01
Vapor Temperature ($^\circ\text{C}$)	28.6		
Barometric Pressure (mm Hg) (kPa)	740.9 (99)		
Vapor Temperature ($^\circ\text{C}$) (corrected to 760 mm Hg) (101 kPa)	29.4		

The compositions of the invention are useful as solvents in a variety of vapor degreasing, cold cleaning and solvent cleaning applications including defluxing.

Claims

1. Azeotrope-like compositions having boiling points of $29.4 \pm 0.1^\circ\text{C}$ at about 765 mm Hg (102 KPa) and comprising 93 to 98 weight percent of 1,1-dichloro-1-fluoroethane, 2 to 7 weight percent of methanol and 0.01 to 0.1 weight percent of nitromethane.
2. An azeotrope-like composition according to Claim 1 characterised by comprising 95.0 to 97.0 weight percent of 1,1-dichloro-1-fluoroethane, 3 to 5 weight percent of methanol and 0.01 to 0.1 weight percent of nitromethane.
3. An azeotrope-like composition according to Claim 1 characterised by comprising about 96.0 weight percent of 1,1-dichloro-1-fluoroethane, about 3.9 weight percent of methanol and about 0.01 weight percent of nitromethane.



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4. A method of cleaning a solid surface which comprises treating said surface with an azeotrope-like composition according to any one of Claims 1 to 3.

Patentansprüche

- 5 1. Azeotropähnliche Zusammensetzungen mit Siedepunkten von $29,4 \pm 0,1^\circ\text{C}$ bei etwa 765 mm Hg (102 kpa), welche 93 bis 98 Gewichtsprozent an 1,1-Dichlor-1-Fluoräthan, 2 bis 7 Gewichtsprozent Methanol und 0,01 bis 0,1 Gewichtsprozent Nitromethan aufweisen.
- 10 2. Azeotropähnliche Zusammensetzung nach Anspruch 1, dadurch gekennzeichnet, daß sie 95,0 bis 97,0 Gewichtsprozent 1,1-Dichlor-1-Fluoräthan, 3 bis 5 Gewichtsprozent Methanol und 0,01 bis 0,1 Gewichtsprozent Nitromethan aufweist.
- 15 3. Azeotropähnliche Zusammensetzung nach Anspruch 1, dadurch gekennzeichnet, daß sie etwa 96,0 Gewichtsprozent 1,1-Dichlor-1-Fluoräthan, etwa 3,9 Gewichtsprozent Methanol und ungefähr 0,01 Gewichtsprozent Nitromethan aufweist.
- 20 4. Verfahren zum Reinigen einer festen Oberfläche, welches das Behandeln der Oberfläche mit einer azeotropähnlichen Zusammensetzung nach einem der Ansprüche 1 bis 3 umfaßt.

Revendications

- 25 1. Compositions analogues à un azéotrope ayant des points d'ébullition de $29,4 \pm 0,1^\circ\text{C}$ à environ 765 mm de Hg (102 KPa) et comprenant 93 à 98 % en poids de 1,1-dichloro-1-fluoroéthane, 2 à 7 % en poids de méthanol et 0,01 à 0,1 % en poids de nitrométhane.
- 30 2. Composition analogue à un azéotrope selon la revendication 1, caractérisée en ce qu'elle comprend 95,0 à 97,0 % en poids de 1,1-dichloro-1-fluoroéthane, 3 à 5 % en poids de méthanol et 0,01 à 0,1 % en poids de nitrométhane.
- 35 3. Composition analogue à un azéotrope selon la revendication 1, caractérisée en ce qu'elle comprend environ 96,0 % en poids de 1,1-dichloro-1-fluoroéthane, environ 3,9 % en poids de méthanol et environ 0,01 % en poids de nitrométhane.
- 40 4. Procédé de nettoyage d'une surface solide qui comprend le traitement de ladite surface avec une composition analogue à un azéotrope selon l'une quelconque des revendications 1 à 3.

