

Description

The invention relates to a process for separating a fluid feed mixture containing hydrocarbon oil and an organic solvent.

It is known to separate various hydrocarbon compounds from feed mixtures containing said compounds and a solvent by contacting the feed mixture at elevated pressure with one (feed) side of a membrane and recovering solvent and optionally one or more hydrocarbon compounds from the other (permeate) side of the membrane. See for instance EP-A 160 142.

However, a major disadvantage of said known separation processes is that a sharp separation into a solvent fraction and a single hydrocarbon oil fraction is not attained therewith; hydrocarbons remain present at both sides of the membranes. Moreover, in case a feed mixture with a relatively high solvent:oil ratio has to be separated, it would be necessary to employ relatively large membrane areas to obtain a given quantity of solvent-poor hydrocarbon oil at the feed side of the membrane.

Surprisingly, it has now been found that the afore-mentioned disadvantages can be overcome by contacting said fluid feed mixture with one side of a hydrocarbon oil-selective membrane which is substantially impermeable to the organic solvent(s) present in the feed mixture and recovering hydrocarbon oil permeate from the other side of the membrane.

Accordingly, the present invention provides a process for separating a fluid feed mixture containing hydrocarbon oil containing molecules having at least 10 carbon atoms and an organic solvent having at most 9 carbon atoms which may be substituted by one or more heteroatoms selected from oxygen, nitrogen or sulphur, which comprises contacting said fluid feed mixture at elevated pressure with one side of a hydrocarbon oil-selective membrane which is substantially impermeable to said organic solvent and recovering hydrocarbon oil permeate from the other side of the membrane.

The process according to the invention is preferably carried out as a reverse osmosis - or a dialysis - process; however, it can also be carried out using other methods known in the art.

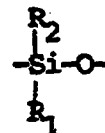
In a reverse osmosis process, in which a difference in hydraulic pressure between both sides of the membrane is maintained as the driving force, various types of membrane units may be applied such as a flat sheet or a tubular membrane unit. Flat membranes are less attractive in case the osmotic pressure is relatively high because said membranes would need to be relatively thick or be supported by a support material having relatively small pores in order to have sufficient strength to withstand the applied pressure differences, and consequently the permeate flux through flat membranes would be relatively low in this case. Moreover, such configurations require a relatively large amount of volume because their packing density (m^2 membrane/ m^3 apparatus) is low. Preference is given to the application of spirally wound- or hollow fibre-membranes which have a high packing density and can with-

stand a relatively high pressure difference between both sides of the membrane for a given wall thickness.

The pressure difference applied between the one side of the membrane contacted with the fluid feed mixture (the feed-side) and the other (permeate) side is preferably from 2-200 bar, and most preferably from 10-80 bar.

The temperature at which the present process is carried out may vary within a wide range and is not critical as long as the applied membranes can withstand the operating conditions. A fluid feed temperature from -40°C to $+400^\circ\text{C}$ is suitable in most cases, whereas a temperature from -20°C to $+300^\circ\text{C}$, in particular from 0°C to 100°C , is preferred.

It has been found that membranes containing a layer of a specific silicone polymer as described hereinafter are particularly suitable as oil selective membranes for application in the process according to the invention. Said silicone polymer comprises units according to the general formula:



wherein R_1 and R_2 represent moieties independently chosen from the group consisting of hydrogen, alkyl, aryl and aralkyl moieties, advantageously having 1-10 carbon atoms per moiety. Suitable aryl groups include phenyl and naphthyl groups. Suitable aralkyl groups include alpha-phenyl ethyl and in particular benzyl groups. Preferably, R_1 and R_2 represent the same or different C_1 - C_{10} -alkyl moieties. A particularly preferred silicone polymer for use as membrane (layer) in the process according to the invention is poly dimethyl siloxane which is highly oil-selective and through which only a relatively small fraction of organic solvent permeates.

The membrane suitably comprises the silicone compound as described hereinbefore in the form of a cross-linked polymer; however, a copolymer of said silicone compound and an elastomeric prepolymer may be used instead.

Various elastomers such as (synthetic) rubbers, polystyrene, polybutadiene or copolymers of styrene and butadiene can also be applied as oil-selective membrane layers per se in the process according to the invention.

The oil-selective membrane layer applied in the present process is preferably substantially non-porous (dense) in order to avoid permeation of substantial amounts of organic solvent through said layer. The membrane layer which is substantially impermeable to said organic solvent preferably has a thickness from 0.1 - $100\ \mu\text{m}$, and most preferably from 1 - $10\ \mu\text{m}$, in order to attain relatively high hydrocarbon oil permeate fluxes therethrough.

The use of reinforcing filler in the hydrocarbon oil-selective membrane layer is preferably avoided because of a possible negative influence thereof on the permeability of said membrane layer. A mem-

brane with excellent strength for the present purpose can be obtained by supporting the silicone layer by means of a porous support which may contain a layer of any suitable material, such as cloth, wire net or glass fibres. A porous polypropylene support layer is preferred in case a silicone polymer is applied as non-porous membrane layer in view of the adhesive bond which can be attained between these two layers; such a support layer suitably has a thickness from 10-500 μm , and preferably from 15-100 μm . In some cases it may be advantageous to apply at least one extra layer between a dense, hydrocarbon-oil selective layer and a porous support; this intermediate layer is suitably a dense highly permeable layer with a good bonding capacity for both the selective layer and the support.

Dense membrane layers comprising a silicone compound suitable for use in the separation process according to the invention may be prepared by any method known in the art. A suitable method is solvent casting which involves forming a solution of a polymer or a prepolymer of the desired membrane compound in a solvent (to which a surface active agent is usually added) and casting the solution onto a liquid support to produce a thin layer which is subsequently dried (by evaporation of the solvent present in the (pre)polymer solution). The applied solvent is generally substantially immiscible in the liquid support in order to avoid a reduction of the surface tension of the liquid support which could lead to instability of the developing membrane and possible generation of holes therein.

Water is a preferred supporting liquid, in particular when used in combination with a prepolymer which can be cross-linked in the presence of water. Most preferably a prepolymer solution of dimethyl siloxane in 3-heptanone is allowed to spread out over a water surface and form a cross-linked, dense membrane layer.

The process according to the present invention is well suited for applications in which a feed solution comprising hydrocarbon oil dissolved in an organic solvent is available as such. This is the case when hydrocarbon oils have been subjected to a solvent dewaxing treatment during which e.g. a toluene/methyl ethyl ketone solvent mixture is added to a wax-containing oil, followed by removing wax (e.g. by means of filtration). The present process is particularly suitable, however, for separating a fluid feed mixture which has been obtained by subjecting a hydrocarbon oil to an extraction treatment with an organic solvent, in particular furfural. The solvents are usually recovered from the hydrocarbon oil-containing feed mixture in a conventional flashing process with high energy consumption. With the process according to the present invention it is possible to reduce said energy consumption considerably by recovering a major portion of the solvent from the feed side of the membrane and separating only a minor portion of the solvent (which has permeated through the membrane) from the hydrocarbon oil permeate by conventional means (e.g. stripping or (flash) distillation).

Preferably, the nature of the organic solvent and hydrocarbon oil is selected such that the solubility

of the hydrocarbon oil in the solvent is limited and as a result of the low permeation rate of solvent through the applied membranes the organic solvent:hydrocarbon oil weight ratio in the permeate is then such that demixing occurs, i.e. a phase separation between an organic solvent fraction and a hydrocarbon oil fraction. A demixed permeate containing a major hydrocarbon oil fraction and a minor organic solvent fraction can then suitably be recovered from the "other" (permeate) side of the membrane and said fractions can subsequently be separated; the organic solvent fraction may be recycled (suitably together with solvent retained at the "one" side of the membrane) to e.g. a solvent extraction unit or solvent dewaxing unit.

The organic solvent used in the process of the present invention is an organic compound which has at most 9 carbon atoms and which may be substituted by one or more heteroatoms selected from oxygen, nitrogen and sulphur. Suitable solvents include linear, branched, carbocyclic and heterocyclic compounds which may be aliphatic or aromatic. Advantageously the solvent contains at least one oxygen atom and/or is aromatic. Preferably the organic solvent is phenol, toluene, furfural or a ketone such as a di C₁₋₄ alkyl ketone in which the alkyl groups may be the same or different. Suitable ketones include acetone, ethyl methyl ketone, methyl isopropyl ketone and butyl methyl ketone.

The hydrocarbon oil present in the fluid feed mixture which is to be separated preferably contains a lubricating base oil. However, other hydrocarbon oils such as gas oils, kerosenes or deasphalted oils can also be present in the fluid feed mixture.

The solvents:hydrocarbon oil weight ratio in the feed solution is suitably from 1:1-40:1, and preferably from 5:1-30:1.

The present separation process can be applied in single- or multi-step operation. In order to avoid, or at least reduce fouling and concentration polarization of the membranes, the feed solution is preferably passed along one side of a membrane with a sufficiently high velocity and may subsequently be passed along one side of at least one following membrane.

In order to prevent concentration polarization even better, part of the feed solution which has been passed along one side of a membrane is preferably recirculated by reintroducing said part into the feed solution to be passed along said side of the same membrane.

The invention further relates to hydrocarbon oils whenever obtained by a separation process as described hereinbefore.

Moreover, the invention relates to hydrocarbon oil-selective membranes whenever used in a process as described hereinbefore. The following example illustrates the invention.

EXAMPLE

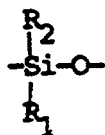
A liquid feed mixture containing 4% by weight of lubricating base oil in furfural is contacted at a pressure of 40 bar abs. and a temperature of 35°C

with the free side of a non-porous polydimethyl siloxane membrane layer supported by a porous polypropylene layer having slit-shaped pores of $0,2 \times 0,02 \mu\text{m}$. A permeate is obtained which is demixed and of which the hydrocarbon oil fraction contains 6% by weight of furfural.

Claims

1. Process for separating a fluid feed mixture containing hydrocarbon oil containing molecules having at least 10 atoms carbon oil and an organic solvent having at most 9 carbon atoms which may be substituted by one or more heteroatoms selected from oxygen, nitrogen or sulphur, which comprises contacting said fluid feed mixture at elevated pressure with one side of a hydrocarbon oil-selective membrane which is substantially impermeable to said organic solvent and recovering hydrocarbon oil permeate from the other side of the membrane.

2. Process according to claim 1 wherein the membrane contains a layer of a silicone polymer comprising units according to the general formula:



wherein R_1 and R_2 represent moieties independently chosen from the group consisting of hydrogen, alkyl, aryl and aralkyl moieties.

3. Process according to claim 2 wherein the silicone polymer is polydimethyl siloxane.

4. Process according to any one of the preceding claims wherein the membrane applied contains at least a non-porous layer.

5. Process according to any one of the preceding claims wherein the pressure difference applied between the one side of the membrane contacted with the fluid feed mixture and the other side is from 2-200 bar.

6. Process according to any one of the preceding claims wherein the fluid feed mixture has been obtained by subjecting a hydrocarbon oil to a extraction treatment with an organic solvent, in particular furfural.

7. Process according to any one of the preceding claims wherein the fluid feed mixture contains a lubricating base oil.

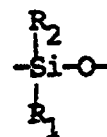
8. Process according to any one of the preceding claims wherein a demixed permeate containing a major hydrocarbon oil fraction and a minor organic solvent fraction is recovered from the other side of the membrane and said fractions are separated.

Patentansprüche

1. Verfahren zur Auftrennung eines flüssigen Einsatzgemisches, das Kohlenwasserstofföl, enthaltend Moleküle mit wenigstens 10 Kohlenstoffatomen, und ein organisches Lösungsmittel enthält, das höchstens 9 Kohlenstoffatome aufweist, die durch

ein oder mehrere Heteroatome, ausgewählt unter Sauerstoff, Stickstoff oder Schwefel, substituiert sein können, welches Verfahren ein In-Kontakt-Bringen des genannten flüssigen Einsatzgemisches bei erhöhtem Druck mit einer Seite einer Kohlenwasserstofföl-selektiven Membran, die für das organische Lösungsmittel im wesentlichen undurchlässig ist, und ein Gewinnen von Kohlenwasserstofföl-Permeat von der anderen Seite der Membran umfaßt.

2. Verfahren nach Anspruch 1, worin die Membran eine Schicht aus einem Silikonpolymer enthält, das Einheiten gemäß der allgemeinen Formel:



umfaßt, worin R_1 und R_2 Reste darstellen, die unabhängig voneinander aus der aus Wasserstoff, Alkyl, Aryl und Aralkyl bestehenden Gruppe ausgewählt sind.

3. Verfahren nach Anspruch 2, worin das Silikonpolymer Polydimethylsiloxan ist.

4. Verfahren nach einem der vorstehenden Ansprüche, worin die angewendete Membran wenigstens eine nicht-poröse Schicht enthält.

5. Verfahren nach einem der vorstehenden Ansprüche, worin der zwischen der einen, mit dem flüssigen Einsatzgemisch in Kontakt stehenden Seite der Membran und der anderen Seite der Membran angelegte Druckunterschied von 2 bis 200 bar beträgt.

6. Verfahren nach einem der vorstehenden Ansprüche, worin das flüssige Einsatzgemisch durch Vornahme einer Extraktionsbehandlung an einem Kohlenwasserstofföl mit einem organischen Lösungsmittel, insbesondere Furfural, erhalten worden ist.

7. Verfahren nach einem der vorstehenden Ansprüche, worin das flüssige Einsatzmaterial ein Schmiermittel-Grundöl enthält.

8. Verfahren nach einem der vorstehenden Ansprüche, worin ein entmischtes Permeat, das eine Hauptfraktion aus Kohlenwasserstofföl und eine Nebenfraktion aus organischem Lösungsmittel enthält, auf der anderen Seite der Membran gewonnen wird und diese Fraktionen aufgetrennt werden.

Revendications

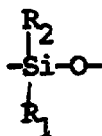
1. Procédé pour séparer un mélange de charge fluide contenant une huile d'hydrocarbures contenant des molécules ayant au moins 10 atomes de carbone et un solvant organique ayant au maximum 9 atomes de carbone qui peuvent être remplacés par un ou plusieurs hétéro-atomes choisis parmi l'oxygène, l'azote et le soufre, qui comprend la mise en contact du mélange de charge fluide à pression élevée avec un côté d'une membrane sélective pour l'huile d'hydrocarbures qui est substantiellement imperméable au solvant organique et le recueil d'un per-

with the free side of a non-porous polydimethyl siloxane membrane layer supported by a porous polypropylene layer having slit-shaped pores of $0,2 \times 0,02 \mu\text{m}$. A permeate is obtained which is demixed and of which the hydrocarbon oil fraction contains 6% by weight of furfural.

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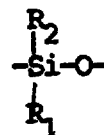
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8. Verfahren nach einem der vorstehenden Ansprüche, worin ein entmischtes Permeat, das eine Hauptfraktion aus Kohlenwasserstofföl und eine Nebenfraktion aus organischem Lösungsmittel enthält, auf der anderen Seite der Membran gewonnen wird und diese Fraktionen aufgetrennt werden.

Revendications

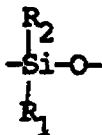
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méat d'huile d'hydrocarbures de l'autre côté de la membrane.

2. Procédé selon la revendication 1, dans lequel la membrane contient une couche d'un polymère de silicone comprenant des mailles de la formule générale:

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où R_1 et R_2 représentent des portions choisies indépendamment dans le groupe constitué par l'hydrogène et des portions alcoyle, aryle et aralcoyle.

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3. Procédé selon la revendication 2, dans lequel le polymère de silicone consiste en polydiméthylsiloxane.

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4. Procédé selon l'une quelconque des revendications précédentes, dans lequel la membrane utilisée contient au moins une couche non poreuse.

5. Procédé selon l'une quelconque des revendications précédentes, dans lequel la différence de pression appliquée entre le côté de la membrane mis en contact avec le mélange de charge fluide et l'autre côté est comprise entre 2 et 200 bars.

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6. Procédé selon l'une quelconque des revendications précédentes, dans lequel le mélange de charge fluide a été obtenu en soumettant une huile d'hydrocarbures à un traitement d'extraction par un solvant organique, en particulier le furfural.

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7. Procédé selon l'une quelconque des revendications précédentes, dans lequel le mélange de charge fluide contient une huile lubrifiante de base.

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8. Procédé selon l'une quelconque des revendications précédentes, dans lequel un perméat présentant une démixtion contenant une fraction majeure d'huile d'hydrocarbures et une fraction mineure de solvant organique est recueilli de l'autre côté de la membrane et ces fractions sont séparées.

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