timeframe. In addition, the cut-off regime of conventional filters is such that only particles are removed and not any molecular matter. Moreover, when conventional filters become clogged/fouled, they must be disposed of, together with the clogging/fouling material, which may have an adverse impact on the environment.

[0012] There is a need for an improved process for pre-treating renewable feedstocks.

SUMMARY OF THE INVENTION

[0013] According to one aspect of the present invention, there is provided a process for pre-treating renewable feedstocks for the production of fuels and/or chemicals, the process comprising the steps of: (a) providing an oil derived from a renewable source, the oil having a contaminant; (b) providing a hydrophilic nanofiltration membrane; and (c) filtering the oil with the nanofiltration membrane to produce a permeate oil having a reduced concentration of the contaminant.

BRIEF DESCRIPTION OF THE DRAWINGS

[0014] The process of the present invention will be better understood by referring to the following detailed description of preferred embodiments and the drawings referenced therein, in which:

[0015] Fig. 1 illustrates one embodiment of the process of the present invention having a single nanofiltration unit;

[0016] Fig. 2 illustrates another embodiment of the process of the present invention having a staged nanofiltration unit;

[0017] Fig. 3 illustrates a further embodiment of the process of the present invention having a self-cleaning filter unit preceding a nanofiltration unit;

[0018] Fig. 4 illustrates still another embodiment of the process of the present invention having a polishing unit following a nanofiltration unit;

[0019] Figs. 5 and 6 are graphical illustrations depicting permeability vs. permeate recovery for different operating pressures in Example 2 herein; and

[0020] Fig. 7 is a graphical illustration depicting the effect of a backpulse on permeability over time in Example 2 herein.

DETAILED DESCRIPTION OF THE INVENTION

[0021] In accordance with the process of the present invention, an oil derived from a renewable feedstock is pre-treated to remove at least a portion of one or more contaminants by filtering the oil with a hydrophilic nanofiltration membrane. The resulting permeate oil has a reduced concentration of the contaminant relative to the feed stream to the nanofiltration membrane. A further advantage of the process of the present invention is that the separation method also contributes the overall sustainability of the renewable feedstock process. Membrane and related filtration separation processes are pressure-driven processes to achieve the required mass-transfer for the separation. This in comparison to other separation methods, such as distillation, whereby the mass-transfer has a temperature-driven relation. These methods are often engaged with the application of fossil fuels for heat generation. Conversely, in membrane and related filtration separation methods, electricity is utilized, which creates the opportunity to apply this separation from a sustainable electrification source, such as derived via solar panel and /or windmill methods. These sustainable energy delivery options will further contribute to support the objective of the desired reduction of the global carbon footprint.

Oils derived from renewable sources

[0022] The renewable feedstock includes materials suitable for the production of fuels, fuel components and/or chemical feedstocks. A preferred class of renewable materials are bio-renewable fats and oils comprising triglycerides, diglycerides, monoglycerides and free fatty acids or fatty acid esters derived from bio-renewable fats and oils. Examples of such fatty acid esters include, but are not limited to, fatty acid methyl esters, fatty acid ethyl esters. The renewable fats and oils include vegetable oils, animal oils and combination thereof, including both edible and non-edible fats and oils. Examples of these renewable fats and oils include, without limitation, algal oil, brown grease, canola oil, carinata oil, castor oil, coconut oil, colza oil, corn oil, cottonseed oil, fish oil, hempseed oil, jatropha oil, lard, linseed oil, milk fats, mustard oil, olive oil, palm oil, peanut oil, rapeseed oil, sewage sludge, soy oils, soybean oil, sunflower oil, tall oil, tallow, used cooking oil, yellow grease and combinations thereof.

[0023] Another preferred class of renewable materials are oils derived from biomass and waste liquefaction processes. Examples of such liquefaction processes include, but are

not limited to, (hydro)pyrolysis, hydrothermal liquefaction, plastics liquefaction, and combinations thereof.

[0024] The oils derived from renewable feedstocks often contain contaminants. As a result, many conventional processes require good quality feedstocks that meet certain specifications before processing. This requirement increases the price of desirable feedstock, as well leaving an untapped resource of undesirable feedstocks.

[0025] Contaminants may include, without limitation, free solids; phosphorus, chlorine, sodium, iron, magnesium, calcium, aluminum, copper, manganese, silicon and/or zinc, in elemental or molecular form; phospholipids, and combinations thereof.

[0026] The process of the present invention is applicable to all oils derived from renewable vegetable and animal feedstocks. However, the inventive process is particularly advantageous for pre-treating renewable feedstocks that are heavily contaminated with contaminants such as, solids, metals and/or gum-like materials. Such heavily contaminated renewable feedstocks, in particular, include tallow, used cooking oil, and combinations thereof.

Nanofiltration membrane

[0027] In the present invention, a hydrophilic nanofiltration membrane is provided and used to filter the oil derived from a renewable source. Generally, it would be understood that a hydrophobic membrane would be appropriate for filtering hydrocarbon streams (see, for example, US6488856). Further, it is generally understood that hydrophobic nanofiltration membranes are less prone to fouling. The inventors have surprisingly discovered that a hydrophilic nanofiltration membrane provides improved performance in the pre-treatment of renewable feedstocks.

[0028] The material of the membrane is selected to be compatible with the components contained in the liquid hydrocarbon feedstock stream. Preferably, the nanofiltration membrane is an inorganic membrane, a polymer membrane, or a combination thereof. More preferably, the nanofiltration membrane is a ceramic membrane or a composite ceramic membrane.

[0029] Nanofiltration membranes have an asymmetric structure. An asymmetric structure provides an amorphous pore network with a smallest or controlling pore size that could be suitable for the process.

CLAIMS

1. A process for pre-treating renewable feedstocks for the production of fuels and/or chemicals, the process comprising the steps of:
providing an oil derived from a renewable source, the oil having a contaminant;
providing a hydrophilic nanofiltration membrane; and
filtering the oil with the nanofiltration membrane to produce a permeate oil having a reduced concentration of the contaminant.

2. The process according to claim 1, wherein the nanofiltration membrane has an average size of at most 30 nm, preferably in a range of from 5 nm to 30 nm, more preferably in a range of from 10 to 30 nm.

3. The process according to claim 1, wherein the nanofiltration membrane has a molecular weight cut-off value in a range of from 8,000 to 100,000 Da, more preferably in a range of from 8,500 to 20,000 Da.

4. The process according to claim 1, wherein the nanofiltration membrane is a ceramic nanofiltration membrane.

5. The process according to claim 2, wherein the ceramic nanofiltration is a functionalized ceramic membrane.

6. The process according to claim 1, wherein the nanofiltration membrane is a composite of a polymer and a support selected from the group consisting up porous polymer, a porous cross-linked polymer, a porous pyrolyzed polymer, a porous pyrolyzed cross-linked polymer, a porous metallic structure, a hybrid metallic-polymer porous structure, a porous ceramic structure, and combinations thereof.

7. The process according to claim 1, wherein the filtering step comprises a first nanofiltration membrane and a second nanofiltration membrane, wherein the first nanofiltration membrane is the same or different than the second nanofiltration membrane.

8. The process according to claim 1, wherein the contaminant is selected from free solids; phosphorus, chlorine, sodium, iron, magnesium, calcium, aluminum, copper, manganese, silicon and/or zinc, in elemental or molecular form; phospholipids, and combinations thereof.

9. The process according to claim 1, wherein the oil derived from a renewable source is selected from vegetable oils, animal oils, and combinations thereof.

10. The process according to claim 9, wherein the oil derived from a renewable source is selected from the group consisting of tallow, used cooking oil, and combinations thereof.

11. The process according to claim 1, further comprising the step of periodically backpulsing the nanofiltration membrane, preferably wherein the backpulsing is conducted with a pulse of pressure in a range of from 10 to 15 bar (1 to 1.5 MPa), preferably for a pulse time in a range from 1 to 5 seconds, preferably on a periodic basis in a range of from 10 to 30 minutes.

12. The process according to claim 1, further comprising the step of backwashing the nanofiltration membrane.

13. The process according to claim 1, further comprising the steps of removing solids before filtering the oil with the nanofiltration membrane by pre-coat filtration, conventional backwash filtration, centrifuge, a self-cleaning filtration unit, and combinations thereof, preferably by providing a self-cleaning filter and directing the oil to the self-cleaning filter before filtering the oil with the nanofiltration membrane.

14. The process according to claim 13, further comprising the step of periodically backwashing the self-cleaning filter.