

PURIFICATION OF RECYCLED AND RENEWABLE ORGANIC MATERIAL

FIELD OF THE INVENTION

The present invention relates to a method of purifying recycled or renewable organic material, in particular recycled or renewable organic material comprising one or more impurities selected from a group consisting of silicon compounds, phosphorous compounds, chlorine compounds and metals.

BACKGROUND OF THE INVENTION

In some cases recycled or renewable organic material contains high amounts of silicon (Si) as silicon compounds and high amounts of phosphorous as phosphorous compounds such as phospholipids. Before catalytic processing of the recycled or renewable organic material these impurities need to be removed from the material as these compounds are known catalyst poisons and should therefore be removed prior to hydrotreating to maximize the cycle length and profits of the hydrotreater.

BRIEF DESCRIPTION OF THE INVENTION

An object of the present invention is thus to provide a method so as to overcome the above problems. The objects of the invention are achieved by a method which is characterized by what is stated in the independent claims. The preferred embodiments of the invention are disclosed in the dependent claims.

The invention is based on the surprising realization recycled or renewable organic material containing high amounts of phosphorous and silicon compounds may be purified by a method that leads to removal of phosphorous and silicon compounds from the recycled or renewable organic material as the recycled or renewable organic material is subjected to heat treating the recycled or renewable organic material at 100 to 450°C and filtering the material and hydrotreating the heat treated recycled or renewable organic material in a presence of a hydrotreating catalyst.

BRIEF DESCRIPTION OF THE DRAWINGS

In the following the invention will be described in greater detail by means of preferred embodiments with reference to the attached drawings, in which

Figure 1 illustrates a first exemplary process flow of the present method.

Figure 2 illustrates a second exemplary process flow of the present method;

Figure 3 illustrates effect of acid treatment on Si and P removal from crude TOP samples;

5 Figure 4 illustrates effect of heat treatment on Si and P removal from crude TOP samples.

DETAILED DESCRIPTION OF THE INVENTION

The present invention provides a method of purifying a recycled or renewable organic material.

10 The term "recycled or renewable organic material" refers to organic material, i.e. material containing carbon, obtained 1) from a natural resource which replenishes to overcome recourse depletion caused by its usage and consumption or 2) from a raw or processed material that is recovered from a waste for reuse. The recycled or renewable organic material characteristically comprises
15 aliphatic compounds having a carbon chain of from 4 to 30 carbon atoms, particularly from 12 to 22 carbon atoms. Typical examples of such aliphatic compounds are fatty acids or esters thereof, in particular wherein the fatty acids have an aliphatic chain of from 4 to 30 carbon atoms, more particularly from 12 to 22 carbon atoms. The recycled or renewable organic material typically comprises at
20 least 50 wt% aliphatic compounds of the total weight of the recycled or renewable organic material.

Typically the recycled or renewable organic material refers to fats and/or oils of plant, microbial, algal and/or animal origin. It also refers to any waste stream received from processing of such oils and/or fats. The recycled or
25 renewable organic material may be in an unprocessed form (e.g. animal fat), or a processed form (used cooking oil). The recycled or renewable organic material also refers to fossil waste-based oils and waste oils.

The term "plant based fats and oils" refers to fat and/or oils of plant origin i.e. oils that can originate directly from plants or can be byproducts from
30 various industrial sectors, such as agriculture or forest industry.

Examples of plant based fats and oils of the present invention include, but are not limited to, sludge palm oil, rapeseed oil, canola oil, colza oil, sunflower oil, soybean oil, hemp oil, olive oil, linseed oil, cottonseed oil, mustard oil, palm oil, arachis oil, castor oil and coconut oil.

Other examples of plant based fats and oils include biocrudes and bio oils. Biocrudes and bio oils are produced from biomass, in particular from lignocellulosic biomass, with various liquefying methods, such as hydrothermal liquefaction, or pyrolysis, in particular fast pyrolysis.

5 The term "biocrude" refers to oils produced from biomass by employing hydrothermal liquefaction. The term "bio oil" refers to pyrolysis oils produced from biomass by employing pyrolysis. The term "biomass" refers to material derived from recently living organisms, which includes plants, animals and their byproducts. The term "lignocellulosic biomass" refers to biomass derived from
10 plants or their byproducts. Lignocellulosic biomass is composed of carbohydrate polymers (cellulose, hemicellulose) and an aromatic polymer (lignin).

 The term "pyrolysis" refers to thermal decomposition of materials at elevated temperatures in a non-oxidative atmosphere. The term "fast pyrolysis" refers to thermochemical decomposition of biomass through rapid heating in absence of oxygen. The term "hydrothermal liquefaction" (HTL) refers to a thermal
15 depolymerization process used to convert wet biomass into crude-like oil under moderate temperature and high pressure.

 Examples of bio oil and biocrude produced from lignocellulosic biomass, e.g. materials like forest harvesting residues or byproducts of a saw mill,
20 are lignocellulosic pyrolysis liquid (LPL), produced by employing fast pyrolysis, and HTL-biocrude, produced by employing hydrothermal liquefaction.

 Further examples of plant based fats and oils include crude tall oil (CTO), obtained as a by-product of the Kraft process (wood pulping), and its derivatives, such as tall oil pitch (TOP), crude fatty acid (CFA), tall oil fatty acid
25 (TOFA) and distilled tall oil (DTO).

 Crude tall oil comprises resin acids, fatty acids, and unsaponifiables. Resin acids are a mixture of organic acids derived from oxidation and polymerization reactions of terpenes. The main resin acid in crude tall oil is abietic acid but abietic derivatives and other acids, such as primaric acid are also found. Fatty acids are long chain monocarboxylic acids and are found in hardwoods and soft-
30 woods. The main fatty acids in crude tall oil are oleic, linoleic and palmitic acids. Unsaponifiables cannot be turned into soaps as they are neutral compounds which do not react with sodium hydroxide to form salts. They include sterols, higher alcohols and hydrocarbons. Sterols are steroids derivatives which also include a hydroxyl group.
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The term "tall oil pitch (TOP)" refers to residual bottom fraction from crude tall oil (CTO) distillation processes. Tall oil pitch typically comprises from 34 to 51 wt% free acids, from 23 to 37 wt% esterified acids, and from 25 to 34 wt% unsaponifiable neutral compounds of the total weight of the tall oil pitch.

5 The free acids are typically selected from a group consisting of dehydroabietic acid, abietic and other resin acids. The esterified acids are typically selected from a group consisting of oleic and linoleic acids. The unsaponifiable neutral compounds are typically selected from a group consisting of diterpene sterols, fatty alcohols, sterols, and dehydrated sterols.

10 The term "crude fatty acid (CFA)" refers to fatty acid-containing materials obtainable by purification (e.g., distillation under reduced pressure, extraction, and/or crystallization) of CTO.

The term "tall oil fatty acid (TOFA)" refers to fatty acid rich fraction of crude tall oil (CTO) distillation processes. TOFA typically comprises mainly fatty acids, typically at least 80 wt% of the total weight of the TOFA. Typically TOFA
15 comprises less than 10 wt% rosin acids.

The term "distilled tall oil (DTO)" refers to resin acid rich fraction of crude tall oil (CTO) distillation processes. DTO typically comprises mainly fatty acids, typically from 55 to 90 wt%, and rosin acids, typically from 10 to 40 wt%
20 rosin acids, of the total weight of the DTO. Typically DTO comprises less than 10 wt% unsaponifiable neutral compounds of the total weight of the distilled tall oil.

The term "animal based fats and oils" refers to fats and/or oils of animal origin i.e lipid materials derived from animals. Examples of animal based fats and oils include, but are not limited to, such as suet, tallow, blubber, lard, train oil,
25 milk fat, fish oil, poultry oil and poultry fat.

The term "microbial oils" refers to triglycerides (lipids) produced by microbes.

The term "algal oils" refers to oils derived directly from algae.

30 The term "fossil waste-based oils" refers to oils produced from waste streams like waste plastics or end-life-tires. Examples of fossil waste-based oils include waste plastic pyrolysis oil (WPPPO) and end-life-tire pyrolysis oil (ELTPO).

The term "waste oils" refers to any oils that, through contamination, have become unsuitable for their original purpose due to the presence of impurities or loss of original properties. Examples of waste oils are used lubricant oils
35 (ULO), hydraulic oils, transformer oils or oils used in metal working.

In the present invention the recycled or renewable organic material is typically selected from a group consisting of plant based fats and oils, animal based fats and oils, fossil waste-based oils, waste oils, algal oils and microbial oils.

Particular examples of the recycled or renewable organic material of the present invention include, but are not limited to, animal based fats and oils, such as suet, tallow, blubber, lard, train oil, milk fat, fish oil, poultry oil, and poultry fat; plant based fats and oils, such as sludge palm oil, rapeseed oil, canola oil, colza oil, sunflower oil, soybean oil, hemp oil, olive oil, linseed oil, cottonseed oil, mustard oil, palm oil, arachis oil, castor oil, coconut oil, lignocellulosic pyrolysis liquid (LPL), HTL biocrude, crude tall oil (CTO), tall oil pitch (TOP), crude fatty acid (CFA), tall oil fatty acid (TOFA) and distilled tall oil (DTO); microbial oils; algal oils; recycled fats or various waste streams of the food industry, such as used cooking oil, yellow and brown greases; free fatty acids, any lipids containing phosphorous and/or metals, oils originating from yeast or mold products, recycled alimentary fats; starting materials produced by genetic engineering, and any mixtures of said feedstocks.

In an example is the present invention the recycled or renewable organic material is selected from a group consisting of tall oil derivatives and pyrolysis oils; in particular from a group consisting of tall oil pitch (TOP),), hydrothermal liquefaction oil (HTL), lignocellulose pyrolysis oils, AF oil, used crude oil (UCO), used lubricating oil (ULO), waste plastic pyrolytic oil (WPPPO), pyrolysis oil from end-of-life tyres (ELT), algae oils, and lignin oils; more particularly the recycled or renewable organic material is tall oil pitch (TOP).

In particular, the recycled or renewable organic material is tall oil pitch (TOP).

The recycled or renewable organic material to be treated by the present method contains high amounts of silicon compounds. The recycled or renewable organic material of the present invention comprises more than 1 ppm silicon compounds. In particular the recycled or renewable organic material of the present invention comprises more than 10 ppm silicon compounds, more particularly the recycled or renewable organic material of the present invention comprises more than 15 ppm silicon compounds, and even more particularly the recycled or renewable organic material of the present invention comprises more than 20 ppm silicon compounds.

The recycled or renewable organic material to be treated by the present method further contains high amounts of phosphorous compounds. The

phosphorous compounds present in the biomass-based lipid material are typically phospholipids. The phospholipids present in the biomass-based lipid material are in particular one or more of phosphatidyl ethanolamines, phosphatidyl choline, phosphatidyl inositols, phosphatidic acids, and phosphatidyl ethanolamines.

5 In particular the recycled or renewable organic material of the present invention comprises from 1 to 1000 ppm phosphorous as phosphorous compounds.

The recycled or renewable organic material to be treated by the present method contains high amounts of chloride (Cl). Typically chloride is present
10 in the form of chloride salts and/or organic chloride compounds, such as chlorinated hydrocarbons. The recycled or renewable organic material of the present invention comprises more than 20 ppm Cl, in particular more than 50 ppm Cl, more particularly from 50 to 1000 ppm Cl. Furthermore, the recycled or renewable organic material to be treated by the present method contains high amounts
15 oxygen as organic oxygen compounds.

The recycled or renewable organic material to be treated by the present method may also comprise further impurities e.g. impurities comprising phosphorus and/or metals in the form of phospholipids, soaps and/or salts. The
20 impurities may for example be in the form of phosphates or sulfates, iron salts or organic salts, soaps or phospholipids. The metal impurities that may be present in the biomass-based lipid material are for example alkali metals or alkali earth metals, such as sodium or potassium salts, or magnesium or calcium salts, or any compounds of said metals.

Accordingly provided herein is a method of purifying a recycled or renewable organic material, wherein the recycled or renewable organic material
25 comprises one or more impurities selected from a group consisting of silicon compounds, phosphorous compounds, chlorine compounds, nitrogen compounds, sulfur compounds, and hydroxyaromatic compounds, comprising the steps of

- (a) providing the recycled or renewable organic material;
- 30 (b) optionally pre heat treating the recycled or renewable organic material at 180 to 325°C, and optionally adding acid before or after the pre heat treatment process, and optionally filtering the pre heat treated recycled or renewable organic material after the pre heat treatment;
- (c) heat treating the recycled or renewable organic material at 150 to
35 450°C, optionally in the presence of an adsorbent, optionally adding water before or during the heat treatment process, and optionally adding acid before or after

the heat treatment process, and optionally filtering the heat treated recycled or renewable organic material after the heat treatment;

(d) optionally evaporating volatile silicon compounds from the heat treated recycled or renewable organic material compounds thereby reducing the silicon content of the heat treated recycled or renewable organic material;

(e) optionally thermally cracking the recycled or renewable organic material thereby reducing the oxygen and phosphorous content of the heat treated recycled or renewable organic material and optionally removing volatiles from the thermally cracked recycled or renewable organic material, and optionally removing solids/precipitates from the recycled or renewable organic material; and

(f) hydrotreating the heat treated recycled or renewable organic material in a presence of a hydrotreating catalyst;

to obtain purified hydrotreated recycled or renewable organic material.

Prior to heat treatment in step (c) the recycled or renewable organic material may be subjected to a pre heat treatment in absence of adsorbent material. In optional step (b) the recycled or renewable organic material is heated to cause thermal reactions that disrupt silicon containing impurities comprised in the recycled or renewable organic material creating volatile silicon compounds material that can be subsequently removed from the recycled or renewable organic material. In particular polydimethylsiloxanes (PDMS) resulting from anti-fouling agents degrade to volatile polydimethylcyclsiloxanes (PDMCS) under the process conditions.

The heat treatment of step (b) takes place at any temperature from 180 to 325°C. For achieving optimal results, step (b) is performed at 200 to 300°C, preferably at 240 to 280°C.

The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 300 min, preferably from 5 to 90 min, more preferably from 20 to 40 min in step (b).

The pressure in the heat treatment in step (b) is typically from 500 to 5000 kPa, preferably from 800 to 2000 kPa.

Optionally, the process can be further enhanced by acid addition before or after pre heat treatment in step (b). This removes any remaining sodium impurities. The acid is preferably selected from citric acid and phosphoric acid.

In step (b) the solid material created due to the heat treatment and/or adsorbent comprising undesired impurities may be removed. Removal of the solid material may be achieved for example by any separation method found suitable by a skilled person for separation of the solid material from the heat treated recycled or renewable organic material. Suitable examples include, but are not limited to, filtration, centrifugation and phase separation. It is also to be understood that several separation methods, e.g. filtration and centrifugation, may be combined. Preferably the removal is accomplished by filtration. The removal is preferably performed at any temperature from 100 to 180°C.

Removal of solids/precipitates avoids deactivation of the hydrotreating catalyst in hydrotreatment of the recycled or renewable organic material.

In step (c) the recycled or renewable organic material is heated at any temperature from 100 to 450°C. For achieving optimal results, step (c) is performed at from 180 to 325°C, preferably from 200 to 300°C, more preferably at from 240 to 280°C.

The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 300 min, preferably from 5 to 240 min, more preferably from 30 to 90 min in step (c).

The pressure in step (c) is typically from 500 to 5000 kPa, preferably from 800 to 2000 kPa.

In step (c) the recycled or renewable organic material is heated to cause thermal reactions that disrupt the structure of the impurity containing compounds comprised in the recycled or renewable organic material thus forming material that adsorbs into the adsorbent present in the heating step (c), or material that forms solid precipitates and that can thus be subsequently removed from the recycled or renewable organic material.

Adsorbent is optionally present in step (c). The adsorbent present in step (c) may be selected from silica-based adsorbents. Preferably the adsorbent is selected from a group consisting of alumina silicate, silica gel and mixtures thereof. In step (c) the amount of adsorbent is typically from 0.1 wt% to 10 wt%, preferably from 0.5 to 2.0 wt-%, of the total weight of the treated recycled or renewable organic material.

In step (c) the solid material created due to the heat treatment and/or adsorbent comprising undesired impurities may be removed. Removal of the solid material may be achieved for example by any separation method found suitable

by a skilled person for separation of the solid material from the heat treated recycled or renewable organic material. Suitable examples include, but are not limited to, filtration, centrifugation, and phase separation. It is also to be understood that several separation methods, e.g. filtration and centrifugation, may be combined.

5 Preferably the removal is accomplished by filtration. The removal is preferably performed at any temperature from 100 to 180°C.

Removal of solids/precipitates avoids deactivation of the hydrotreating catalyst in hydrotreatment of the recycled or renewable organic material.

10 In particular when adsorbent is present in step (c), it is advantageously removed. Thus optionally after the heat treatment the adsorbent comprising the undesired impurities is removed. Accordingly in step (c) the recycled or renewable organic material is subjected to removal of the solid adsorbent material. Removal of the solid material may be achieved for example by any separation method found suitable by a skilled person for separation of the solid material
15 from the heat treated recycled or renewable organic material. Suitable examples include, but are not limited to, filtration, centrifugation, and phase separation. It is also to be understood that several separation methods, e.g. filtration and centrifugation, may be combined. The removal is preferably performed at any temperature from 100 to 180°C.

20 Optionally, the process can be further enhanced by acid addition before or after heat treatment in step (c). This removes any remaining sodium impurities. The acid is preferably selected from citric acid and phosphoric acid.

Further optionally in step (c) process may be enhanced by adding water to the material before or during the heat treatment process. In step (c) the
25 water content in the feed, i.e. the recycled or renewable organic material may advantageously vary in from 500 to 5000 ppm. If the recycled or renewable organic material comprises more than 5000 ppm water, it may be removed from the feed before step (c) by any suitable means known to a skilled person for lowering the water content in the recycled or renewable organic material below 5000ppm.

30 For example (c1) the recycled or renewable organic material provided in step (a), comprising more than 20 ppm Cl, may be heated in the presence of an aqueous solution of alkaline metal hydroxide at a temperature from 100 to 450°C to obtain the purified recycled or renewable organic material comprising (iii) less than 50% of the original chlorine content of the recycled or renewable organic
35 material provided in step (a).

In step (c1) the recycled or renewable organic material is heated to cause thermal reactions that degrade chloride containing impurities, in particular chlorinated organic hydrocarbons. The heat treatment of step (c1) takes place at any temperature from 100 to 450°C. For achieving optimal results, step (c1) is performed at from 150 to 400°C, preferably at from 200 to 300°C.

For (c1) the time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 180 min, preferably from 2 to 90 min, more preferably from 5 to 60 min in step (c1).

The alkaline metal hydroxide is typically selected from a group consisting of KOH, LiOH, NaOH and mixtures thereof. The alkaline metal hydroxide is preferably NaOH. The concentration of the aqueous alkaline metal hydroxide is typically from 0.1 to 10.0 mol/L. The ratio of the aqueous solution of alkaline metal hydroxide to the treated recycled or renewable organic material in step (c1) is typically more than 0.1 g/g, preferably from 0.5 to 1.5 g/g.

After heating the organic and aqueous fractions may be separated by any suitable method known to a skilled person to obtain the purified recycled or renewable organic material comprising less than 50% of the chlorine content of the recycled or renewable organic material provided in step (a).

Alternatively step (c) is accomplished by (c2) heat treating the recycled or renewable organic material at a temperature between 250 to 450°C, preferably from 350 to 450°C, to obtain heat treated the recycled or renewable organic material.

Further alternatively step (c) is accomplished by (c3) heat treating recycled or renewable organic material, preferably at 180 to 325°C, to form a heat treated recycled or renewable organic material, wherein the at least part of silicon compounds present in the recycled or renewable organic material are converted to volatile silicon compounds.

In (c3) the recycled or renewable organic material is heated to cause thermal reactions that disrupt silicon containing impurities comprised in the recycled or renewable organic material creating volatile silicon compounds material that can be subsequently removed from the heat treated recycled or renewable organic material. In particular polydimethylsiloxanes (PDMS) resulting from anti-fouling agents degrade to volatile polydimethylcyclsiloxanes (PDMCS) under the process conditions.

The heat treatment of step (c3) typically takes place at any temperature from 180 to 325°C. For achieving optimal results, step (c3) is performed at 200 to 300°C, preferably at 240 to 280°C.

5 The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 300 min, preferably from 5 to 90 min, more preferably from 20 to 40 min in step (c3).

The pressure in the heat treatment in step (c3) is typically from 500 to 5000 kPa, preferably from 800 to 2000 kPa.

10 The pressure range in step (c3) is dictated by volatility of water and it is advantageous to keep the heat treatment pressure slightly higher than the balance pressure of water boiling in particular heat treatment temperature. Too low pressure may drive volatile components like water and fractions of fatty acids into gas phase. Carry over of organic volatiles is enhanced by presence of water or stripping.

15 An applicable step (c3) preferably provides purified recycled or renewable organic material advantageously comprising (i) less silicon than the recycled or renewable organic material provided in step (a), preferably less than 10%, more preferably less than 5%, even more preferably less than 1%, of the original silicon content of the recycled or renewable organic material provided in step (a).

In yet further example step (c) is accomplished by (c4) heating the recycled or renewable organic material at any temperature from 180 to 325°C in presence of an adsorbent. For achieving optimal results, step (c4) is performed at 25 200 to 300°C, preferably at 240 to 280°C.

The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 300 min, preferably from 5 to 240 min, more preferably from 30 to 90 min in step (c4).

30 In step (c4) the recycled or renewable organic material is heated to cause thermal reactions that disrupt the structure of the impurity containing compounds comprised in the recycled or renewable organic material thus forming material that adsorbs into the adsorbent present in the heating step (c), or material that forms solid precipitates and that can thus be subsequently removed from the recycled or renewable organic material.

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The adsorbent present in step (c4) may be selected from silica-based adsorbents. Preferably the adsorbent is selected from a group consisting of alumina silicate, silica gel and mixtures thereof. In step (d4) the amount of adsorbent is typically from 0.1 to 10.0 wt-%, preferably 0.5 to 2.0 wt%, of the total weight of the treated recycled or renewable organic material.

An applicable step (c4) preferably provides purified recycled or renewable organic material comprising (ii) less than 30 % of the original phosphorous content of the recycled or renewable organic material provided in step (a)

After the heat treatment in step (c) the volatiles created due to the heat treatment and/or otherwise present in the heat treated recycled or renewable organic material may be removed. Accordingly in optional step (d) the heat treated recycled or renewable organic material is subjected to evaporation of the volatile silicon compounds from the heat treated recycled or renewable organic material in one or more stages. In step (d) the evaporation is advantageously achieved at any temperature from 145 to 250°C, in particular at from 150°C to 225°C. For achieving optimal results, the evaporation in step (d) is performed at from 160°C to 200°C, preferably at from 160 to 180°C.

The reduced pressure in step (d) is such that evaporation of volatile Si compounds is achieved. Typically the pressure is from 0.1 to 5 kPa, preferably from 0.1 to 3 kPa.

The evaporated mass should be arranged to evaporation of 1 to 10 wt%, preferably from 1 to 8 wt%, more preferably from 1 to 5 wt%, even more preferably from 1 to 3 wt%, of the heat treated recycled or renewable organic material.

Furthermore, it is preferable to add water to the initial mixture of the heat treated recycled or renewable organic material. Adding a small percentage of water to the initial heat treated recycled or renewable organic material allows use of lower temperature and higher vacuum pressure while achieving the same level of Si removal than in normal evaporation. Even more importantly, there is less loss of volatile fatty acids, which reduces the amount of fatty acid waste to half compared to evaporation without water.

Accordingly in an example of the present invention water is added to the heat treated recycled or renewable organic material so that water content before evaporation step (d) is from 1 to 5 wt%, preferably from 1.5 to 4 wt% more preferably from 2 to 3 wt% of the total weight of the heat treated recycled or renewable organic material.

An applicable step (d) provides a vapor fraction comprising the major part of volatile silicon compounds, and a heat treated recycled or renewable organic material fraction comprising less than 50%, preferably less than 30%, of the original silicon content of the recycled or renewable organic material provided in step (a).

The evaporation in step (d) may be accomplished by any evaporation method found suitable by a skilled person for separation of the volatiles from the heat treated recycled or renewable organic material. Suitable examples include, but are not limited to, falling film evaporation, rising film evaporation, thin film evaporation and flash evaporation, for example. The evaporation may be accomplished in one or more stages. It is also to be understood that several evaporation methods, e.g. thin film evaporation and flash evaporation, may be combined. Preferable evaporation method of the present invention is one or multi stage flash evaporation. Due to high pressure difference in flash vessel, less evaporation mass is needed in flash evaporation to provide better mass transfer as compared to thin film evaporation. For example, applying the same method and equipment as in a typical crude tall oil (CTO) thin film evaporation process for tall oil pitch (TOP) after heat treatment remarkably increases heat consumption as compared to flash evaporation.

The optimum temperature, pressure, evaporated mass and how many flash stages to use depends on composition and quality of the recycled or renewable organic material and also on the heat treatment parameters (temperature, pressure and residence time) of step (c).

After desirable heat treatment and optionally evaporation of volatile silicon compounds is achieved the heat treated recycled or renewable organic material may be subjected to further purification by thermal cracking.

In optional step (e) the recycled or renewable organic material is heated to cause thermal cracking of the recycled or renewable organic material disrupting phosphorus compounds comprised in the recycled or renewable organic material creating a solid material that can be subsequently removed from the heat treated recycled or renewable organic material e.g. by filtration.

The thermal cracking of step (b) may be performed in a separate reactor unit or in hydrotreating reactor before catalyst bed at a guard bed.

Accordingly in step (e) the recycled or renewable organic material is thermally cracked thereby reducing the oxygen content of the recycled or renewable organic material and phosphorous content of the recycled or renewable organic material.

5 The thermal cracking of step (e) typically takes place at any temperature from 350 to 450°C.

 The thermal cracking of step (e) takes place in an apparatus enabling sufficient residence time. The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is
10 typically from 1 to 300 min, preferably from 5 to 240 min, more preferably from 30 to 90 min in step (e).

 The pressure in step (e) is such that sufficient oxygen removal is achieved. Typically the pressure in step (e) is from 4 to 20 MPa, preferably from 8 to 16 MPa.

15 After the thermal cracking in step (e) the volatiles created due to the thermal cracking and/or otherwise present in the recycled or renewable organic material may be removed. Accordingly in step (e) the thermally cracked recycled or renewable organic material is optionally subjected to removing volatiles from the thermally cracked recycled or renewable organic material. This can be
20 achieved in one or more stages. Typical examples of the volatiles include CO and CO₂.

 Removal of the volatiles may be achieved for example by any separation method found suitable by a skilled person for separation of the volatiles from the thermally cracked recycled or renewable organic material. Suitable examples
25 include, but are not limited to, evaporation, in particular flash evaporation and thin film evaporation.

 The optimum temperature, pressure, evaporated mass and how many flash stages to use depends on composition and quality of the recycled or renewable organic material and also on the thermal cracking parameters (temperature,
30 pressure and residence time) of step (e).

 The temperature and pressure in step removal of volatiles in step (e) is such that evaporation of volatile oxygen compounds is achieved. In step (e) the removal of volatiles is typically achieved at any temperature from 300 to 450°C. For achieving optimal results, removing of volatiles in step (e) is performed at
35 from 350°C to 450°C. Typically the pressure in removing volatiles in step (e) is from 0.1 to 5 kPa, preferably from 0.1 to 3 kPa.

Removal of volatiles reduces the amount of oxygen in the recycled or renewable organic material.

After the thermal cracking in step (e) the solid material created due to the thermal cracking may be removed. Accordingly in step (e) the thermally cracked recycled or renewable organic material is optionally subjected to removing solids/precipitates from the thermally cracked recycled or renewable organic material.

Removal of the solid material may be achieved for example by any separation method found suitable by a skilled person for separation of the solid material from the thermally cracked recycled or renewable organic material. Suitable examples include, but are not limited to, filtration, centrifugation, *bleaching*, *degumming* and phase separation. It is also to be understood that several separation methods, e.g. filtration and centrifugation, may be combined. Preferably the removal is accomplished by filtration. The removal of is preferably performed at any temperature from 100 to 180°C.

Removal of solids/precipitates, in particular those comprising phosphorous, avoids deactivation of the hydrotreating catalyst in hydrotreatment of the recycled or renewable organic material.

An applicable step (e) preferably provides purified recycled or renewable organic material comprising (iv) less than 30% of the original phosphorous content of the recycled or renewable organic material provided in step (a).

After the step (c) the purified recycled or renewable organic material is subjected to (f) to hydrotreatment to further remove Cl from the recycled or renewable organic material..

The term "hydrotreating" refers to a chemical engineer process in which reaction of hydrogen is used to remove impurities, such as oxygen, sulfur, nitrogen, phosphorous, silicon and metals, especially as part of oil refining.

Hydrotreating can be performed in one or several steps in one or more reactor units or catalyst beds.

Step (f) is typically achieved under continuous hydrogen flow. For achieving optimal results the continuous hydrogen flow in step (f) preferably has H₂/feed ratio from 500 to 2000 n-L/L, more preferably from 800 to 1400 n-L/L.

In step (f) hydrotreatment is advantageously performed at a temperature from 270 to 380°C, preferably from 275 to 350°C, more preferably from 300 to 330°C. Typically the pressure in step (f) is from 4 to 20 MPa.

The hydrotreating catalyst is step (f) preferably comprises at least one component selected from IUPAC group 6, 8 or 10 of the Periodic Table.. Preferably the hydrotreating catalyst in step (f) is a supported Pd, Pt, Ni, NiW, NiMo or a Co-Mo catalysts and the support is zeolite, zeolite-alumina, alumina and/or silica, preferably NiMo/Al₂O₃ or CoMo/Al₂O₃. In particular the hydrotreating catalyst is a sulfided NiW, NiMo or CoMo catalyst.

The time during which the recycled or renewable organic material is heated and held at the desired temperature, i.e. residence time, is typically from 1 to 300 min, preferably from 5 to 240 min, more preferably from 30 to 90 min in step (e).

An applicable hydrotreatment step (f) provides a purified hydrotreated recycled or renewable organic material, wherein the purified hydrotreated recycled or renewable organic material comprises (i) less than 10%, preferably less than 5%, more preferably less than 1%, of the original silicon content of the recycled or renewable organic material provided in step (a) and/or (ii) less than 30% of the original phosphorous content of the recycled or renewable organic material provided in step (a) and/or (iii) less than 20 ppm chlorine or less than 50% of the chlorine content of the recycled or renewable organic material provided in step (a) and/or (iv) less than 30% of the original phosphorous content of the recycled or renewable organic material provided in step (a).

In a particular example step (f) is accomplished by (f1) hydrodeoxygenating (HDO) the heat treated recycled or renewable organic material fraction. This is preferably achieved in a presence of a HDO catalyst at a temperature from 270 to 380°C under pressure from 4 to 20 MPa and under continuous hydrogen flow. Preferably step (f1) is performed to obtain purified recycled or renewable organic material comprising less than 1 wt% oxygen.

The term "hydrodeoxygenation (HDO)" refers to removal of oxygen as water by the means of molecular hydrogen under the influence of a (HDO) catalyst.

The HDO catalyst may for example be selected from a group consisting of NiMo-, CoMo-, NiW-catalysts and any mixtures thereof. Preferably the HDO catalyst in step (f) is sulfided NiW, sulfided NiMo or sulphided NiMo-catalyst.

Advantageously, the continuous hydrogen flow has H₂/feed ratio from 500 to 2000 n-L/L, preferably from 800 to 1400 n-L/L.

For achieving optimal results part of the deoxygenated recycled or renewable organic material may be recycled in step (f1). Preferably the ratio of the fresh feed i.e. purified recycled or renewable organic material obtained in step (f1) to the recycled deoxygenated recycled or renewable organic material is from
5 2:1 to 20:1.

When step (f) is accomplished by (f1) hydrodeoxygenating (HDO) the heat treated recycled or renewable organic material fraction in a presence of a HDO catalyst at a temperature from 290 to 350°C under pressure from 4 to 20 MPa and under continuous hydrogen flow preferably purified recycled or renewable organic material comprising less than 1 wt% of oxygen and/or less than
10 20%, preferably less than 10%, more preferably less than 5%, of the original silicon content of the recycled or renewable organic material provided in step (a) and/or less than 30% of the original phosphorous content of the recycled or renewable organic material provided in step (a) and/or less than 50% of the chlorine content of the recycled or renewable organic material provided in step (a) is
15 obtained.

In another example step (d) is accomplished by (d2) hydrodesulfurizing (HSD) the heat treated recycled or renewable organic material fraction. The term “hydrodesulfurisation (HDS)” refers to removal of sulfur as hydrogensulfide
20 by the means of molecular hydrogen under the influence of a (HDS) catalyst.

In another example step (d) is accomplished by (d3) hydrometallizing (HDM) the heat treated recycled or renewable organic material fraction. The term “hydrodemetallization (HDM)” refers to removal of metals by trapping them with a (HDM) catalyst.

25 In another example step (d) is accomplished by (d4) hydrodenitrificating (HDN) the heat treated recycled or renewable organic material fraction. The term “hydrodenitrification (HDN)” refers to removal of nitrogen by the means of molecular hydrogen under the influence of a (HDN) catalyst.

30 In another example step (d) is accomplished by (d5) hydrodesaromatizing (HDA) the heat treated recycled or renewable organic material fraction. The term “hydrodearomatisation (HDA)” refers to saturation or ring opening of aromatics by the means of molecular hydrogen under the influence of a (HDA) catalyst.

35 Figure 1 illustrates a first exemplary process flow of the present method.

Referring to Figure 1, a feed of recycled or renewable organic material, in particular tall oil pitch (TOP), 10 is subjected to a step of pre heat treating 20 the recycled or renewable organic material as discussed herein for step (b) to obtain a heat treated recycled or renewable organic material fraction 21renewable organic material. The pre heat treated recycled organic material 21 is then sub-
5 jected to heating 30 the recycled or renewable organic material the presence of adsorbent to adsorb the impurities to the adsorbent and to render the mixture separable as discussed herein for step (c). The adsorbent is then separated 40 from the treated feed of recycled or renewable organic material as discussed
10 herein for step (c) to obtain a purified recycled or renewable organic material 41 and an adsorbent 42 comprising the major part of the impurities. The purified recycled or renewable organic material is then hydrotreated 50, as discussed herein for step (f) to obtain a purified hydrotreated recycled or renewable organ-
ic material 51, wherein the purified hydrotreated recycled or renewable organic
15 material comprises less than 50% of the impurity content of the recycled or re-
newable organic material provided in step (a). The purified hydrotreatedrecycled or renewable organic material 51 may then be subjected to catalytic upgrading
60.

Figure 2 illustrates a first exemplary process flow of the present meth-
20 od.

Referring to Figure 2, a feed of recycled or renewable organic material, in particular tall oil pitch (TOP), 10 is subjected to a step of pre heat treating 20 the recycled or renewable organic material as discussed herein for step (b) to ob-
tain a heat treated recycled or renewable organic material fraction 21 comprising
25 less than 50% of the impurity content of the recycled or renewable organic mate-
rial provided in step (a). The pre heat treated recycled organic material 21 is then subjected to a step of heat treating 35 the recycled or renewable organic material as discussed herein for step (c). The heat treated feed of recycled or renewable organic material is then evaporated 45 as discussed herein for step (c) and a bot-
30 tom containing a heat treated recycled or renewable organic material fraction 46 comprising less than 30% of the original silicon content of the recycled or renew-
able organic material provided in step (a), and a vapor fraction 47 comprising the major part of volatile silicon compounds is obtained. The purified recycled or re-
newable organic material is then hydrodeoxygenated 50, as discussed herein for
35 step (d) to obtain a purified deoxygenated recycled or renewable organic material 51, wherein the purified deoxygenated recycled or renewable organic material.

The deoxygenated recycled or renewable organic material 51 may then be subjected to catalytic upgrading 60.

After the recycled or renewable organic material has been purified in accordance with the present method, it may be subjected to further processing e.g. catalytic upgrading. Such catalytic upgrading processes include, but are not limited to, catalytic cracking, catalytic hydrocracking, thermo-catalytic cracking, catalytic hydrotreatment, fluid catalytic cracking, catalytic ketonization, and catalytic esterification. Such processes require the recycled or renewable organic material to be sufficiently pure and free from impurities that may otherwise hamper the catalytic process or poison the catalyst(s) present in the process.

Accordingly the present invention further provides a process for producing recycled or renewable hydrocarbons, comprising steps of (x) purifying the recycled or renewable organic material as discussed herein, and (y) subjecting the purified recycled or renewable organic material to an oil refinery conversion process, wherein the oil refinery conversion process comprises altering the molecular weight of the feed, such as hydrocracking, or steamcracking, removal of heteroatoms from the feed, such as thermal catalytic cracking, fluid catalytic cracking, or hydrotreating, in particular hydrodeoxygenating, or hydrodesulfurizing, altering the degree of saturation of the feed, such as hydrotreating, thermal catalytic cracking, or fluid catalytic cracking, rearranging the molecular structure of the feed, such as isomerizing, or any combination thereof to obtain at least one recycled or renewable hydrocarbon.

In a typical example of the present process the recycled or renewable hydrocarbon is a renewable traffic fuel or fuel component.

In an example of the present process, step (y) is hydrocracking. In such example, step (y) is preferably performed in a mild hydrocracking (MHC) refinery unit, in particular in a presence of a hydrocracking catalyst.

In another example of the present process, step (y) is steamcracking. In such example step (y) is preferably performed in a steamcracking unit.

In yet another example of the present process, step (y) is isomerization. In such example, step (y) is preferably performed in an isomerization unit.

In yet another example of the present process, step (y) is hydrotreating. In such example, step (y) is preferably performed in a hydrotreating unit.

In yet another example of the present process, step (y) is thermal catalytic cracking (TCC). In such example, step (y) is preferably performed in a thermal catalytic cracking unit.

In yet another example of the present process, step (y) is fluid catalytic cracking (FCC). In such example, step (y) is preferably performed in a fluid catalytic cracking unit.

EXAMPLES

5 Example 1

Crude and heat treated tall oil pitch (TOP) were subjected to distillation under varied conditions. Yield and silicon content of obtained distillate and bottom fractions are shown in Table 1 (reference) for crude TOP and in Table 2 for heat treated TOP.

10 **Table 1**

Crude TOP (Si=54ppm)				
	p (kPa)	T (°C)	Distillate	Bottom
Conditions	0.1	147		
Yield			4%	96%
Si /ppm			100	35
Conditions	1	194		
Yield			6%	94%
Si /ppm			230	35
Conditions	3	222		
Yield			6%	94%
Si /ppm			260	37
Conditions	5	236		
Yield			5%	95%
Si /ppm			280	36

Table 2

Heat-treated TOP (Si=25 ppm)				
	p (kPa)	T (°C)	Distillate	Bottom
Conditions	0.1	145		
Yield			4%	96%
Si /ppm			160	8
Conditions	1	193		
Yield			3%	97%
Si /ppm			260	10
Conditions	3	220		
Yield			5%	95%
Si /ppm			440	11
Conditions	5	235		
Yield			5%	95%
Si /ppm			360	14

As can be seen from Table 1 and 2, silicon content in bottom fraction of heat-treated TOP is significantly lower than crude TOP's.

Example 2

Six tall oil pitch qualities were flash evaporated without water and with water (3%). Process conditions are shown in Table 3 (without water) and Table 4 (with water).

Table 3. Process conditions for the evaporation

Flash conditions	TOP1	TOP2	TOP4	TOP5	TOP6	TOPMIX
T run (°C)	172	184	190	228	218	190
P (kPa)	1	1	1	1	1	1
wt% (bottom)	93.9	91.5	93.3	93.7	93	93.5
wt% (heads)	6.1	8.5	6.7	6.3	7	6.5
wt% of fatty acids (heads)	5.5	6.8	6.2	5.9	6.8	6

Table 4. Process conditions for the evaporation with water addition

Flash conditions	TOP1	TOP2	TOP4	TOP5	TOP6	TOPMIX
Water added (%)	3	3	3	3	3	3
T run (°C)	160	160	160	160	160	160
P (mbar)	50	50	50	50	50	50
w% (bottom)	94.3	93.8	93.6	94.6	95.5	95.4
w% (heads)	5.7	6.2	6.4	5.4	4.5	4.6
w% of fatty acids (heads)	1.8	2.3	2.5	1.1	0.9	1

Table 5. Silicon contents after heat treatment (HT) and flash evaporation

Silicon content, ppm	TOP1	TOP2	TOP4	TOP5	TOP6	TOPMIX
After HT (Feed)	75	76	190	350	26	140
After Flash (without added water)	18	26	32	96	8.5	35
After Flash (3wt% water added)	15	27	32	100	8.6	34

10

The average Si-removal efficiency of the flash evaporation for both with and without water addition was 73% on average for all the 6 TOP qualities tested (Table 5). Even more importantly, there is less loss of volatile fatty acids, which reduces the amount of fatty acid waste to half compared to flashing without water (Table 4).

15

Example 3

Heat treated and flash evaporated TOP samples were hydrotreated (hydrodeoxygenated) in different temperatures. Other process conditions, pressure and weight hourly space velocity (WHSV), were kept constant. Pressure was 5000 kPa and WHSV was 0.95 1/h.

Table 6. Silicon contents of heat treated and flash evaporated TOP before and after HDO

Silicon content, ppm	T=291°C	T=320°C	T=333°C	T=350°C
After HT and flash (Feed)	43	43	43	43
After HDO	4	3.8	1.5	0.6

The Si-removal efficiency of the hydrotreatment for heat treated and flash evaporated TOP increases when temperature is increased (Table 6).

Example 4**High temperature NaOH treatment of waste plastic pyrolysis oil**

The following experiment was carried out in a 1-litre batch autoclave reactor. The waste plastic pyrolysis oil (340 g) and the 2 wt-% aqueous NaOH (227 g) were weighed together into the reactor vessel. After sealing and pressure testing, the reactor that was stirred at 500 rpm was heated to the desired reaction temperature of 240°C, which was then maintained for 30 min. The reactor was subsequently cooled down to room temperature before recovery of products. The contents were decanted from the reactor vessel into centrifugation tubes, and the liquids were centrifuged at 20°C and 4300 rpm for 30 minutes. After the centrifugation, the purified pyrolysis oil was recovered as a separate layer, and analysed for its Cl, Br, S and N content. Cl, Br and S content was determined using X-ray fluorescence spectroscopy, and N content was determined according to standard ASTM D5762. The results, which are presented in Table 7, clearly show that the content of both Cl and Br decrease by more than 60%.

Table 7. Impurity content of waste plastic pyrolysis oil before and after 30 min treatment with 2 wt-% aqueous sodium hydroxide at 240°C

	Original waste plastic pyrolysis oil	Purified waste plastic pyrolysis oil #1	Decrease (%)
N (mg/kg)	770	360	53
Cl (mg/kg)	625	187	70
Br (mg/kg)	307	111	64
S (mg/kg)	1000	911	9

Example 5

Crude TOP was treated in the presence of two adsorbents: alumina silicate (Tonsil 9194 FF) and silica gel (Trisyl). The amount of each adsorbent was 1.5 wt-%. Crude TOP samples from different producers were tested. Water addition of 0.4 wt-% was made prior the high temperature adsorption treatment.

During high temperature adsorption treatment the sample materials were heated to temperature 280 °C for 60 minutes. After this treatment the sample materials were cooled to 100 °C and filtered through a 0.45 µm filter paper.

From the obtained results it can be seen that Si and other impurities can be very efficiently removed from the feed at elevated temperatures in presence of both alumina silicate and silica gel adsorbent. However, more efficient purification was obtained using silica gel material. The results are listed in Table 8. As can be seen from Table 9 and Figure 3 and Figure 4, efficient Si and P removal cannot be achieved by mere acid + heat treatment nor acid + adsorption purification method.

Table 8. Effect of heat treatment adsorption on Si and P removal from different types of crude TOP samples. Adsorbent addition 1.5 wt-%.

		14144865	14225369	14225368
		Crude TOP A	280°C, 1 hour	280°C, 1 hour
?	?			
?	?		1.5 wt.-% Tonsil 9194	1.5 wt.-% Trisyl
Al	mg/kg	7.1	3.7	<0,2
Fe	mg/kg	27	32	2.4
Na	mg/kg	580	150	150
Si	mg/kg	27	3	1.3
Ca	mg/kg	56	13	0.82
Mg	mg/kg	6.2	14	<0.3
P	mg/kg	50	14	<0.6

		14177357	14225371	14225370
		Crude TOP B	280°C, 1 hour	280°C
			1.5 wt.-% Tonsil 9194	1.5 wt.-% Trisyl
Al	mg/kg	10	4	<0,2
Fe	mg/kg	71	50	0.62
Na	mg/kg	740	180	170
Si	mg/kg	130	12	4.4
Ca	mg/kg	41	13	0.57
Mg	mg/kg	7.4	13	<0.3
P	mg/kg	137	21	1.3

Table 9 Effect of acid treatment (Citric acid addition 2000 ppm) and adsorption on Si and P removal from crude TOP sample. Adsorbent addition 2.0 wt-%.

		14151662	14151646
		Crude TOP C	120°C bleaching + cake filtration
?	?		
?	?		2 wt.-% Tonsil 9194
Al	mg/kg	5	0.64
Fe	mg/kg	29	1.1
Na	mg/kg	490	6.9
Si	mg/kg	41	15
Ca	mg/kg	25	4.5
Mg	mg/kg	4.2	1.5
P	mg/kg	73	9.5

It will be obvious to a person skilled in the art that, as the technology advances, the inventive concept can be implemented in various ways. The invention and its embodiments are not limited to the examples described above but may vary within the scope of the claims.

CLAIMS

1. A method of purifying a recycled or renewable organic material, wherein the recycled or renewable organic material comprises one or more impurities selected from a group consisting of silicon compounds, phosphorous compounds, chlorine compounds, nitrogen compounds, sulfur compounds, and hydroxyaromatic compounds, comprising the steps of
- 5 (a) providing the recycled or renewable organic material;
- (b) optionally pre heat treating the recycled or renewable organic material at 180 to 325°C, and optionally adding acid before or after the pre heat treatment process, and optionally filtering the pre heat treated recycled or renewable organic material after the pre heat treatment;
- 10 (c) heat treating the recycled or renewable organic material at 100 to 450°C, optionally in the presence of an adsorbent, optionally adding water before or during the heat treatment process, and optionally adding acid before or after the heat treatment process, and optionally filtering the heat treated recycled or renewable organic material after the heat treatment;
- 15 (d) optionally evaporating volatile silicon compounds from the heat treated recycled or renewable organic material compounds thereby reducing the silicon content of the heat treated recycled or renewable organic material;
- 20 (e) optionally thermally cracking the recycled or renewable organic material thereby reducing the oxygen and phosphorous content of the heat treated recycled or renewable organic material, and optionally removing volatiles from the thermally cracked recycled or renewable organic material, and optionally removing solids/precipitates from the recycled or renewable organic material;
- 25 and
- (f) hydrotreating the heat treated recycled or renewable organic material in a presence of a hydrotreating catalyst;
- to obtain purified hydrotreated recycled or renewable organic material, which comprises (i) less than 20%, preferably less than 10%, more preferably less than 5%, of the original silicon content of the recycled or renewable organic material provided in step (a) and/or (ii) less than 30% of the original phosphorous content of the recycled or renewable organic material provided in step (a) and/or (iii) less than 50% of the chlorine content of the recycled or renewable organic material provided in step (a) renewable organic material.
- 30
- 35

2. A method as claimed in claim 1, wherein step (c) is accomplished by (c1) heating the recycled or renewable organic material in the presence of an aqueous solution of alkaline metal hydroxide at a temperature from 100 to 450°C to obtain the purified recycled or renewable organic material comprising less than 50% of the chlorine content of the recycled or renewable organic material provided in step (a).

3. A method as claimed in claim 2, wherein the temperature in step (c1) is from 150 to 400°C, preferably from 200 to 300°C.

4. A method as claimed in claim 2 or 3, wherein the residence time is from 1 to 180 min, preferably from 2 to 90 min, more preferably from 5 to 60 min in step (c1).

5. A method as claimed in any one of claims 1 to 4, wherein the alkaline metal hydroxide is selected from a group consisting of KOH, LiOH, NaOH and mixtures thereof, preferably the alkaline metal hydroxide is NaOH.

6. A method as claimed in any one of claims 1 to 5, wherein the concentration of the aqueous alkaline metal hydroxide is from 0.1 to 10.0 mol/L and the ratio of the aqueous solution of alkaline metal hydroxide to the treated recycled or renewable organic is more than 0.1 g/g, preferably from 0.5 to 1.5 g/g.

7. A method as claimed in claim 1, wherein step (c) is accomplished by (c2) heat treating the recycled or renewable organic material at a temperature between 250 to 450°C to obtain heat treated the recycled or renewable organic material.

8. A method as claimed in claim 7, wherein step (c2) is performed at 350 to 450°C.

9. A method as claimed in claim 1, wherein step (c) is accomplished by (c3) heat treating the recycled or renewable organic material at 180 to 325°C to form a heat treated recycled or renewable organic material, wherein the at least part of silicon compounds present in the recycled or renewable organic material are converted to volatile silicon compounds

10. A method as claimed in claim 9, wherein heat treatment in step (c3) is performed at 200 to 300°C, preferably at a 240 to 280°C

11. A method as claimed in claim 9 or 10, wherein the residence time, is from 1 to 300 min, preferably from 5 to 90 min, more preferably from 20 to 40 min in heat treatment of step (c3).

12. A method as claimed in any one of claims 9 to 11, wherein the method comprises (d) evaporating volatile silicon compounds from the heat treated recycled or renewable organic material

to obtain

- 5 (i) a vapor fraction comprising the major part of volatile silicon compounds, and (ii) a heat treated recycled or renewable organic material fraction comprising less silicon than the recycled or renewable organic material provided in step (a).

13. A method as claimed in any one of claims 9 to 12, wherein evaporation in step (d) is performed at 150°C to 225°C, preferably at 160°C to 200°C, more preferably at 160 to 180°C.

14. A method as claimed in any one of claims 9 to 13, wherein the pressure in evaporation of step (d) is from 0.1 to 5 kPa, preferably from 0.1 to 3 kPa.

15 15. A method as claimed in any one of claims 9 to 14, wherein in evaporation of step (d) 1 to 10 wt%, preferably from 1 to 8 wt%, more preferably from 1 to 5 wt%, even more preferably from 1 to 3 wt%, of the heat treated recycled or renewable organic material is evaporated.

16. A method as claimed in any one of claims 9 to 15, water is added to the heat treated recycled or renewable organic material so that water content before evaporation step (d) is from 1 to 5 wt%, preferably from 1.5 to 4 wt% more preferably from 2 to 3 wt% of the total weight of the heat treated recycled or renewable organic material.

17. A method as claimed in any one of claims 1 to 16, wherein the temperature in step (c) is from 180 to 325°C., preferably from 200 to 300°C, more preferably preferably from 240 to 280°C.

18. A method as claimed in any one of claims 1 to 17, wherein, wherein the residence time is from 1 to 300 min, preferably from 5 to 240 min, more preferably from 30 to 90 min in step (c).

19. A method as claimed in any one of claims 1 to 18, wherein the adsorbent in step (c) is selected from silica-based adsorbents, preferably from a group consisting of alumina silicate, silica gel and mixtures thereof.

20. A method as claimed in any one of claims 1 to 19, wherein the amount of adsorbent in step (c) is from 0.1 to 10.0 wt-%, preferably 0.5 to 2.0 wt%, of the total weight of the treated recycled or renewable organic material.

21. A method as claimed in any one of claims 1 to 20, wherein acid is added before or after pre heat treatment in step (b).

22. A method as claimed in any one of claims 1 to 21, wherein acid is added before or after heat treatment in step (c).

5 23. A method as claimed in any one of claims 12 to 22, wherein after step (d) silicon content of the heat treated recycled or renewable organic material fraction is less than 50%, preferably less than 30 %, of the original silicon content of the recycled or renewable organic material provided in step (a).

10 24. A method as claimed in claims 1 to 23, wherein hydrotreating step (f) takes place under continuous hydrogen flow.

25. A method as claimed in claim 24, wherein in step (f) the continuous hydrogen flow has H₂/feed ratio from 500 to 2000 n-L/L, preferably from 800 to 1400 n-L/L.

15 26. A method as claimed in any one of claims 1 to 25, wherein step (f) is performed at a temperature from 270 to 380°C, preferably from 275-360°C, more preferably from 300-350°C.

27. A method as claimed in any one of claims 1 to 26, wherein step (f) is performed under pressure from 4 to 20 MPa.

20 28. A method as claimed in any one of claims 1 to 27, wherein the hydrotreating catalyst in step (f) comprises at least one component selected from IUPAC group 6, 8 or 10 of the Periodic Table.

25 29. A method as claimed in any one of claims 1 to 28, wherein the hydrotreating catalyst in step (f) is a supported Pd, Pt, Ni, NiW, NiMo or a CoMo catalysts and the support is zeolite, zeolite-alumina, alumina and/or silica, preferably NiW/Al₂O₃, NiMo/Al₂O₃ or CoMo/Al₂O₃.

30. A method as claimed in any one of claims 1 to 29, wherein step (f) is accomplished by (f1) hydrodeoxygenating (HDO) the heat treated recycled or renewable organic material fraction.

30 31. A method as claimed in claim 30, wherein step (f) is accomplished by (f1) hydrodeoxygenating (HDO) the heat treated recycled or renewable organic material fraction in a presence of a HDO catalyst at a temperature from 290 to 350°C under pressure from 4 to 20 MPa and under continuous hydrogen flow to obtain purified recycled or renewable organic material comprising less than 1 wt% of oxygen and/or less than 20%, preferably less than 10%, more preferably
35 less than 5%, of the original silicon content of the recycled or renewable organic material provided in step (a) and/or less than 30% of the original phosphorous

content of the recycled or renewable organic material provided in step (a) and/or less than 50% of the chlorine content of the recycled or renewable organic material provided in step (a).

32. A method as claimed in any one of claims 30 to 31, wherein in step
5 (f1) the HDO catalyst is sulfided NiW, NiMo or CoMo-catalyst.

33. A method as claimed in any one of claim 1 to 32, wherein a part of the hydrotreated product is recycled in step (f).

34. A method as claimed in claim 33, wherein the ratio of the fresh feed to the hydrotreated product is from 2:1 to 20:1.

10 35. A method as claimed in any one of claim 1 to 34, wherein the recycled or renewable organic material is selected from a group consisting of plant based fats and oils, animal based fats and oils, fossil waste-based oils, waste oils, algal oils and microbial oils.

36. A process for producing recycled or renewable hydrocarbons,
15 comprising steps of

(x) purifying the recycled or renewable organic material as claimed in any one of claims 1 to 35, and

(y) subjecting the purified recycled or renewable organic material to a oil refinery conversion process, wherein the oil refinery conversion process comprises altering the molecular weight of the feed, removal of heteroatoms from the feed, altering the degree of saturation of the feed, rearranging the molecular structure of the feed, or any combination thereof to obtain at least one recycled or renewable hydrocarbon.
20

37. A process as claimed in claim 36, wherein step (y) is hydrocracking.
25

38. A process as claimed in claim 37, wherein step (y) is performed in a mild hydrocracking (MHC) refinery unit.

39. A process as claimed in claim 37 or 38, wherein step (y) is performed in a presence of a hydrocracking catalyst.

30 40. A process as claimed in claim 36 wherein step (y) is steamcracking.

41. A process as claimed in claim 36 wherein step (y) is isomerization.

42. A process as claimed in claim 36 wherein step (y) is hydrotreating.

43. A process as claimed in claim 36 wherein step (y) is thermal catalytic cracking.

35 44. A process as claimed in claim 36 wherein step (y) is fluid catalytic cracking.