

Description

Title of Invention: Production of a hydrocarbon product from aromatic renewable feedstock

Technical Field

[0001] The invention pertains to a method for the production of a hydrocarbon product from a hydrocarbonaceous stream, which comprises feedstock derived from the thermochemical decomposition of a solid material.

Background Art

[0002] The use of solid materials such as lignin, cellulose, hemicellulose, lipids, proteins, and artificial polymers and liquid streams comprising dispersed solids such as sewage sludge as feedstocks for hydrocarbon production has been explored. These solid materials, when subjected to thermochemical decomposition, yield hydrocarbonaceous streams, which have been identified to comprise compounds which may form high molecular weight heavy polynuclear aromatics (HPNA) during hydrocracking conditions, which can lead to catalyst deactivation and fouling of equipment, especially in processes with a hydrocracking step in a recycle configuration.

Summary of Invention

[0003] This unrealized problem is proposed solved by one or more means, including the use of a process step active in hydrodearomatization and a separation step selectively purging HPNA precursors and HPNA from the process.

Definitions

[0004] From the perspective of hydrocracking, unconverted oil (UCO) or unconverted product is the material boiling above a desired, stated or implied end boiling point. Unconverted product from the hydrocracking process step is for this purpose considered a product having a boiling point above the implied limit, irrespective of any chemical conversion of the feed to the product.

- [0005] For hydrocracking process steps the term conversion shall be defined from the mass of "unconverted" product from the hydrocracking process step i.e. the product boiling above a defined limit (m_{UCO}) and the corresponding mass of high boiling feed to the hydrocracking process step i.e. the feed boiling above a defined limit (m_{HBF}). Conversion is calculated as $1 - m_{UCO}/m_{HBF}$, and commonly reported as a percentage value. Commonly the fractionation downstream hydrocracking will define the boiling point limit of "unconverted product".
- [0006] When hydrocracking is carried out in a recycle configuration, in which "unconverted" product is separated and recycled to the inlet of a hydrocracking reactor, conversion is relevantly considered from two perspectives; conversion per pass and overall conversion. Conversion per pass is based on the local analysis of the single reactor, for which m_{UCO} and m_{HBF} are considered at the inlet and outlet of the reactor. Overall conversion is considered from a process step perspective, as the m'_{HBF} , inlet to the overall process step (upstream combination with recycle), and the m'_{UCO} out of the overall process step (the fraction boiling above the implied limit and withdrawn from the process, i.e. excluding the recycled fraction). The overall conversion is calculated as $1 - m'_{UCO}/m'_{HBF}$, and commonly reported as a percentage value.
- [0007] Where boiling point is stated, it may either be initial boiling point or specific % boiling point, in accordance with the definitions of simulated distillation in ASTM D7500. Average boiling point shall be understood as volumetric average boiling point in accordance with the use in the refinery art, e.g. in American Petroleum Institute's Technical Data Book. The initial boiling point (IBP), the final boiling point (FBP) and the temperatures corresponding to recovered amounts of sample, shall be understood in accordance with these ASTM standards. T_x , T_{95} and T_{97} boiling points shall accordingly be understood as the distillation temperatures where X wt%, 95 wt %, and 97 wt % respectively have been recovered. A T_x to T_y fraction shall be understood as the fraction boiling within the temperature range T_x to T_y , and similarly a T_{x+} fraction as the fraction boiling above T_x .
- [0008] The term bubble point shall in accordance with the terminology of the field be considered as the temperature, for a given pressure, at which bubbles of gas are first formed in a hydrocarbon mixture.

[0009] The term stripper shall in accordance with the terminology of the field be considered as a countercurrent multi-stage separation device utilizing an external stripping medium such as steam or gas supplied at the bottom of the tower to facilitate the separation of a feed stream into a lighter lower molecular weight product recovered at the top of the tower and a heavier higher molecular weight product recovered at the bottom of the tower. Typically steam will have a lower temperature than the feed stream to be separated, and thus the light and heavy streams leaving the stripper will have a lower temperature than the feed stream.

[0010] A fractionator shall in accordance with the terminology of the field be considered as a countercurrent multi-stage separation device utilized to separate at least two, but commonly three or more product fractions based on boiling range and relative volatility. The degree of separation in the tower is determined by the combination of reflux rates and number of equilibrium stages employed. External heat is typically applied to the feed stream or the bottom of the tower or to intermediate flows within the tower for purpose of generating the desired reflux flows. A fractionator may in addition be fed a stream of steam or other stripping medium to support separation.

[0011] Where concentrations are stated in wt% or ppmwt this shall be understood as weight/weight % or weight/weight parts per million. For solids and liquid concentrations shall be considered on a weight basis unless otherwise stated.

[0012] A gas/liquid separator shall in accordance with the terminology of the field be considered as a vessel which receives a feed stream consisting of a vapor phase and a liquid phase provides sufficient volumetric holding time for the phases to separate by gravity force and then be separately removed from the vessel in two or more product streams. Commonly a separation section comprising several gas/liquid separators may be configured for separation at different pressure and temperature levels, which may provide more efficient separation and/or higher thermal efficiency. Depending on the content of water in the feed stream, gas/liquid separators may be two-phase separators or three-phase separators, and where the specific embodiments describe three-phase separators in connection with production or addition of water, these may appropriately be considered equivalent with two phase gas/liquid separators if the amount of water present is low, such as below 1 wt%.

- [0013] In the following the elemental concentration of e.g. carbon, hydrogen, oxygen, nitrogen shall be the total mass such an element relative to the total mass of all molecules in the composition.
- [0014] In the following a hydrocarbonaceous feedstock shall be used to signify a feedstock rich in molecules comprising hydrogen and carbon, but possibly also heteroatoms, i.e. other elements, such as oxygen, sulfur and nitrogen.
- [0015] In the following a hydrocarbon shall be used to signify a feedstock rich in hydrogen and carbon, but possibly also containing heteroatoms, i.e. other elements, such as oxygen, sulfur and nitrogen in elemental amounts less than 1 weight%.
- [0016] The H:C atomic ratio shall be understood as the ratio between these elements by elemental analysis of a composition.
- [0017] Polynuclear aromatics (PNA) shall in the following be understood as hydrocarbon compounds having multiple aromatic rings, such as 2 or more.
- [0018] Heavy polynuclear aromatics (HPNA) shall in the following be understood as compounds having at least 7 aromatic rings. PNA shall be understood as including HPNA.
- [0019] Where solid materials are mentioned, this shall also be understood to include dispersed solid materials, such as sewage sludge and manure, in which at least 5 weight% is solid.
- [0020] Where concentrations of aromatics or other groups of molecules are referred to they shall signify the concentration of all the molecules of such a group, and not the functional group.
- [0021] The severity of reaction conditions shall be understood as the extent to which a given reaction will take place. Hydrodesulfurization severity, shall e.g. be understood as being increased if one or more physical or chemical conditions are changed in a way having the consequence that the degree of hydrodesulfurization is increased.
- [0022] .Where process steps are described to “involve” a step this shall be understood as comprising said step as a sub-step.

[0023] The term “comprise” shall be understood as containing in part or in whole, and shall not be understood as excluding other steps or materials.

Technical Problem

[0024] Solid renewable feedstock comprising aromatic structures, such as lignocellulosic biomass including wood products, forestry waste, and agricultural residue may be converted to liquid feedstock by means of thermochemical decomposition. The liquid feedstock may comprise polycyclic aromatic structures, originating from the structure of the solid feedstock. Similar products may also be observed for specific artificial aromatic polymers. Commonly hydrocarbonaceous feedstock derived from a thermochemical decomposition of a solid renewable material, comprises 50-85 wt% C and 3-50 wt% O and an atomic ratio between H and C of less than 1.8 or 1.6.

[0025] In one aspect, the thermal decomposition is hydrothermal liquefaction. Hydrothermal liquefaction means the thermochemical conversion of biomass into liquid fuels by processing in a hot, pressurized water environment for sufficient time to break down the solid bio-polymeric structure to mainly liquid components. Typical hydrothermal processing conditions are temperatures in the range of 250-425°C and operating pressures in the range of 40-350 bar. This technology offers the advantage of operation at a lower temperature, higher energy efficiency and lower tar yield compared to pyrolysis, e.g. fast pyrolysis. Equivalent solvolysis methods exist in which solvents other than water are used.

[0026] In one aspect, the thermal decomposition further comprises passing said solid renewable feedstock through a solid renewable feedstock preparation section comprising for instance drying for removing water and/or comminution for reduction of particle size, especially for processes other than hydrothermal liquefaction, which actively employs water. Any water/moisture in the solid renewable feedstock which vaporizes in for instance the thermal decomposition section condenses in the pyrolysis oil stream and is thereby carried out in the process, which may be undesirable. Furthermore, the heat used for the vaporization of water withdraws heat which otherwise is necessary for the pyrolysis. By removing water and providing a smaller particle size in the solid renewable feedstock, the thermal efficiency of the pyrolysis section is increased.

[0027] The product of thermal decomposition, for simplicity pyrolysis oil, must commonly be upgraded to remove heteroatoms. The physical properties such as boiling point and freezing point of the pyrolysis oil may be satisfactory, such that removal of impurities is the only requirement, which may be carried out by hydrotreatment - the addition of hydrogen without intended breaking of carbon-carbon bonds, such as removal of heteroatoms such as sulfur, oxygen, nitrogen, metals and halogens and saturation of olefins. Such hydrotreatment may beneficially be carried out in the presence of compatible feedstocks, such as liquid hydrocarbonaceous streams of fossil or biological origin.

[0028] The material catalytically active in hydrotreatment, typically comprises an active metal (sulfided base metals such as nickel, cobalt, tungsten and/or molybdenum, but if the hydrocarbon is free of sulfur and nitrogen compounds possibly also elemental noble metals such as platinum and/or palladium and other metals of the platinum group) and a refractory support (such as alumina, silica or titania, or combinations thereof). Hydrotreating conditions typically involve a temperature in the interval 250-460°C, a pressure in the interval 3-30 MPa, and a liquid hourly space velocity (LHSV) in the interval 0.1-5 hr⁻¹ and a GOR (gas to oil ratio) of 300-10000 Nm³/m³ optionally together with intermediate cooling by quenching with cold hydrogen, feed or product. However, for reactive compounds, such as olefins, hydrotreatment may take place at temperatures down to between 100°C and 200°C or 250°C, and to control the reactions; such as polymerization or thermal overheating, it may be necessary to conduct hydrotreatment at such very mild conditions, to reduce reactivity. The severity of hydrotreatment is typically increased by increasing temperature, hydrogen availability (partial pressure and relative flow rate) and the metal content and dispersion on catalysts.

[0029] When the heteroatomic products of hydrotreatment are fluid, such as hydrocarbons and products comprising heteroatoms (such as water, ammonia, hydrochloric acid and hydrogen sulfide) these will leave the reactor and may be separated downstream. When the heteroatomic products are solid (such as released metals, silicon and phosphorous), they will commonly precipitate on the catalytically active material, which therefore preferably is designed to have a

capacity for uptake of such solid heteroatomic compounds, e.g. by high void space, high surface areas and high pore diameters.

[0030] Commonly the molecular structure of pyrolysis oils is modified by hydrocracking. In hydrocracking, carbon-carbon bonds are broken, with the addition of hydrogen, such that the size of molecules is reduced, or rings are opened.

[0031] The material catalytically active in hydrocracking typically comprises an active metal (either elemental noble metals such as platinum and/or palladium or sulfided base metals such as nickel, cobalt, tungsten and/or molybdenum), an acidic support (typically a molecular sieve showing high cracking activity, and having a topology such as MFI, BEA and FAU or amorphous silica-alumina or a combination of such materials) and a refractory support (such as alumina, silica or titania, or combinations thereof). A material catalytically active in isomerization is similar, but the acidic support is of a different structure supporting only specific molecular re-configuration or have a lower acidity e.g. due to silica:alumina ratio, making reactions more specific. Hydrocracking conditions using sulfided catalysts typically involve a temperature in the interval 300–460°C, a pressure in the interval from 3 MPa to 15 MPa, 20 MPa or 30 MPa, a liquid hourly space velocity (LHSV) in the interval 0.5–8 hr⁻¹ and a GOR of 300–5000 Nm³/m³, optionally together with intermediate cooling by quenching with cold hydrogen, feed or product. Hydrocracking conditions using elemental noble metal catalysts typically involve a lower temperature in the interval 230–315°C, but otherwise similar conditions. Hydrocracking and isomerization severity is typically increased by increasing temperature, reduced space velocity, hydrogen availability (partial pressure and relative flow rate), the metal content and dispersion and the acidity of molecular sieve and acidic supports on catalysts. As it is known to the skilled person the hydrocracking severity may be changed to optimize the process with respect to product composition and boiling point, in response to demands from product mix or feedstock characteristics. The choice of catalyst activity may be made to support the desired flexibility in severity.

[0032] As mentioned above hydroprocessing catalysts may comprise noble metals or sulfided base metals. Noble metals (one or both of platinum and palladium – and possibly other metals of the platinum group - IUPAC Groups 8, 9 and 10, periods

5 and 6) are active in the elemental form and active in low amounts, such as 0.05 wt% to 2 wt%. The noble metals are sensitive to the presence of especially sulfur and nitrogen, which may reduce the activity dramatically, and must therefore operate in the presence of less than 50 ppm_{wt} sulfur and nitrogen, which is called sweet mode. Contrary to this, base metals (commonly molybdenum and tungsten, which may be promoted by presence of nickel and cobalt) are active in their sulfided form, requires higher concentrations (2-20 wt% molybdenum and/or tungsten in combination with nickel and/or cobalt in an atomic ratio of 0.2-1.0), and thus very robust in the presence of such heteroatoms (called sour gases) and actually must operate in the presence of more than 50-200 ppm_{wt} sulfur, which is called sour mode. In addition, the acidity of the support of hydrocracking and isomerization catalyst may be reduced by ammonia, being a product of hydrotreatment of hydrocarbons comprising nitrogen, which at moderate levels such as 50 ppb to 50 ppm may be employed to control the selectivity towards middle distillates. At elevated levels a presence of ammonia may be undesired as it will deactivate the cracking and isomerization activity.

[0033] While expectations have been that the oxygen rich structures of renewable materials would not lead to high amounts of HPNA precursors, it has now been discovered that the structure of renewable pyrolysis oil may be of a nature leading to formation of problematic amounts of stable polynuclear aromatic compounds (PNA). In hydrocracking of fossil crude oil, such compounds are known, especially from the processes hydrocracking VGO in a recycle configuration. The quantitative analysis of HPNA is related to uncertainties, but problematic amounts of HPNA are typically in the range of 100 wtppm to 1000 wtppm and above.

[0034] Formation of Heavy Polynuclear Aromatic (HPNA) compounds from PNA is a known issue in hydrocracking processes. They are formed as by-products during undesired side reactions and are characterized by their stability and resistance to conversion into lighter products. HPNA compounds are polycyclic aromatic compounds with 7 or more rings, for example coronenes C₂₄H₁₂, benzocoronenes C₂₈H₁₄, dibenzocoronenes C₃₂H₁₆ and ovalenes C₃₂H₁₄.

[0035] The problems with HPNA compounds arise when their low solubility limit is exceeded. This leads to the formation of solids in transfer lines, valves, and on

heat exchanger surfaces, causing operational difficulties. Moreover, HPNA compounds can contribute to catalyst deactivation by causing irreversible coke formation on active reaction sites.

[0036] The build-up of HPNA compounds in the recycle streams can result in the deactivation of the catalysts and potential fouling of equipment, which can negatively impact the efficiency and productivity of the hydrocracking process. The conventional solution to this problem, removing a portion of the recycle oil stream to purge the HPNA compounds, has its own drawbacks, as it limits the total conversion level achievable in the hydrocracker and requires more purge of unconverted oil than desired.

[0037] To some extent, PNA and HPNA may be converted by hydrodearomatization, in the presence of hydrogen at moderate temperatures, where the equilibrium between aromatics and non-aromatic ring structures from is shifted toward non-aromatics, which then subsequently may be directed to hydrocracking where ring-opening will occur, without formation of HPNA. The equilibrium between aromatic compounds and non-aromatic equivalents favors non-aromatic equivalents at low temperatures and high pressures, and considering the non-reactive nature of PNA and HPNA a high equilibrium push is desired, such as a pressure above 100 bar and a temperature below 350°C.

[0038] The material catalytically active in hydrodearomatization is operated at moderate temperatures, and therefore it is commonly chosen to have a higher hydrogenation activity than the material catalytically active in hydrotreatment, to compensate for the reduced activity due to the lower temperature.

[0039] The effect is preferably obtained by the material catalytically active in hydrodearomatization comprising an elevated amount of active metals, such as from at least 0.1 wt%, at least 0.5 wt% or at least 1 wt%, to 3 wt% Pt or Pd noble metal or from at least 1 wt%, at least 5 wt% or at least 15 wt% to at most 20 wt%, at most 30 wt% or at most 50 wt% molybdenum or tungsten, promoted by an amount of nickel in the range from 0.1:1 Ni:Mo+W to 2:1 Ni:Mo+W (where the ratios designate molar ratios between the amount of Ni and the total amount of Mo and W) on a refractory oxidic support such as alumina, silica, titania, silica-alumina or molecular sieves. The hydrodearomatization catalyst may also

comprise only Ni in reduced form as active metal on a refractory support or may be an unsupported bulk catalyst comprising at least 50% sulfided Mo and/or W. The extent of hydrodearomatization is increased by increasing pressure which is commonly in the range 10-30 MPa, especially hydrogen pressure (which is commonly above 80% of the total pressure), and by increasing the amounts of metals and the dispersion on catalysts. As mentioned, lowering the temperature will shift the equilibrium toward non-aromatics, but will also reduce the activity of catalysts.

[0040] In a conventional recycle hydrocracking process, a heavy feedstock is combined with a hydrogen-rich gas and reacted over a catalyst to lower molecular weight products. The liquid product is separated, e.g. by fractionation, and a heavy fraction is recycled to increase the conversion to desired products. To avoid excessive HPNA build-up, a side stream of the heavy fraction is purged from the process, but it is desired to minimize the amount of non-HPNA in this purge stream, to minimize the yield loss.

[0041] The concentration and speciation of aromatics in a renewable feedstock is complicated by the fact that the standard analytical methods in the field have been optimized for fossil feedstocks. The presence of high amounts of especially oxygen in renewable feedstocks make the results from indirect methods inaccurate, and therefore alternative analytical methods are chosen. One such example is the use of H:C atomic ratio as an indicator of the amount of aromatics in the feedstock. In fossil VGO (vacuum gas oil) the atomic H:C value is commonly higher than 1.6, but lower than 1.8, which is indicative of an elevated aromatic content including the higher aromatics, such as polynuclear aromatics, especially those with four or more rings. In aromatic pyrolysis oils of biological origin, also after hydrotreatment, this ratio may be even lower, such as below 1.6, 1.55 or 1.5.

[0042] The activity of hydrotreatment catalysts is in part related to the composition of the catalyst, but in addition the catalysts may be passivated temporarily or even deactivated permanently by the presence of other compounds. One example of this is that the presence of alkaline organic nitrogen compounds may passivate the catalyst, and therefore deep hydrotreatment to remove such organic nitrogen

compounds may be necessary to ensure high activity of the hydrodearomatization catalyst.

Solution to Problem

[0043] The processing of pyrolysis oils comprising HPNA precursors may be handled in many ways.

[0044] In a simple embodiment, hydrodearomatization is sufficient, especially if formation of HPNA is minimized. This is mainly the case where the content of HPNA precursors in the hydrotreated oil is moderate, as indicated by a H:C ratio higher than 1.6 and lower than 1.8. For this case it is beneficial to minimize the content of nitrogen, especially alkaline organic nitrogen, to ensure maximum activity in catalyzing the equilibrium reaction to form non-aromatic compounds. Depending on the product requirements, this case may be combined with a step of hydrocracking, in which C-C bonds are broken, resulting in ring-opening reactions.

[0045] The operation of a hydrocracker is commonly carried out under conditions favoring from 20% or 40% to 75% or 95% conversion (per pass) of material boiling above the desired end point, with a higher overall conversion such as close to 100% being obtained by recycle of the high boiling fraction. A lower overall conversion such as 80%, 90% or 95% is also relevant especially if the high boiling fraction may be employed in a way creating value.

[0046] In the more demanding case, which is likely the more common, the amounts of HPNA precursors are higher, as indicated by a H:C ratio below 1.6 such as 1.5 or even 1.4. Here ring-opening by employing a hydrocracking catalyst is further required, but at the same time also leading to a risk of additional formation of HPNA. Again, it is desired that hydrodearomatization is carried out upstream the hydrocracking catalyst, which will make the ring-compounds more reactive and thus susceptible to ring-opening, as they would be more reactive than the corresponding aromatic counterparts.

[0047] While the serial step of hydrodearomatization and hydrocracking may contribute to avoiding HPNA formation and the related problems, it is possible that additional steps are required to avoid such problems. One such additional step is related to the recycle of the highest boiling compounds to undergo

hydrocracking. By recycling these compounds around a hydrocracking reactor, an amount of high-boiling compounds will be converted to lower boiling compounds, but the presence of HPNA pre-cursors may lead to a formation of additional HPNA. Therefore a process separating the formed HPNA efficiently from the recycled stream may be introduced. Such a process could involve a stripping process at elevated temperature, which will drive high boiling, non-HPNA compounds into a vapor phase, while the very high boiling HPNA will remain in the liquid phase and may be purged out of the process.

[0048] The amount of non-PNA in the purge stream may be reduced by a high-temperature stripping step. This stripping step may use any stripping medium, but most commonly steam. As steam usually has a temperature below that of the high boiling fraction, this will be cooled in the stripper, which may increase the purged liquid phase. The net purge of unconverted oil may be reduced by heating any stream going into the stripping step, including the stripping medium, the unconverted oil for stripping, any recycle streams or the equipment involved in the stripping step. This step vaporizes a substantial amount of the bottom fraction stream, concentrating HPNA in the heavier bottoms liquid, which is then removed as net purge from the hydrocracker. This process results in a higher total conversion in the hydrocracker and increased yields of valuable distillate products.

[0049] Such a stripping step may either be conducted on a high boiling stream upstream a fractionator, such that the majority of HPNA is diverted from the fractionator or on a the full or partial bottom stream directed for recycle. In both cases a moderate size stripper will enable withdrawal of a sub-stream rich in HPNA from recycle, which thus will reduce the amount of HPNA in the recycle. When the heated stripper is positioned upstream the fractionator, the highest boiling fraction such as the fraction boiling above T95 or T97 will not be part of a recycled stream, as it is diverted to purge.

[0050] Embodiments involving processes separating HPNA possibly together with PNA from an intermediate stream are also relevant. This may be in combination with any of the hydrodearomatization and/or hydrocracking processes mentioned above, especially processes involving recycle of a hydrocracked stream. The separation of HPNA and PNA is preferably done in a heated stripping step.

Brief Description of Drawings

[0051] Fig.1 illustrates a process with hydrodearomatization and hydrocracking of an entire hydrotreated stream.

[0052] Fig.2 illustrates a process with hydrodearomatization of an entire hydrotreated stream and hydrocracking of only a high boiling stream.

[0053] Fig.3 illustrates a process with hydrodearomatization and hydrocracking of a recycled high boiling stream.

[0054] Fig.4 illustrates a process with hydrodearomatization and hydrocracking of a recycled high boiling stream and heated stripping upstream fractionation.

Fig.1

[0055] Figure 1 shows a process layout for producing a hydrocarbon product (140) from a hydrocarbonaceous stream (102). The hydrocarbonaceous stream (102) is derived from a thermochemical decomposition of a solid material (not shown). The solid material may comprise one or more compounds taken from the group comprising lignin, cellulose, hemicellulose, lipids, proteins, and artificial polymers.

[0056] The hydrocarbonaceous stream (102) is combined with make-up hydrogen (116) and a gaseous recycle stream (112) and directed to hydrodenitrification and other reactions in the first stage reactors HDT to provide a reduced content of organically bound nitrogen by contact with a material catalytically active in hydrotreatment under active hydrotreatment conditions to provide a hydrotreated hydrocarbon stream (104). The HDT step may beneficially be carried out in two reactor sections, with intermediate removal of NH_3 commonly by water washing to push the equilibrium towards denitrification.

[0057] This step reduces the potential catalyst passivation of catalytically active material by ammonia and organic nitrogen in downstream reactors. In this way, the method integrates several steps to efficiently produce a hydrocarbon product from a hydrocarbonaceous stream derived from various types of solid materials.

[0058] The hydrotreated hydrocarbon stream (104), is washed by addition of water (106), and separation in a high pressure separator (HPS), from which a gaseous stream, which is split in a gaseous recycle stream (112) and optionally a gaseous purge stream (114), a polar liquid stream (115) and a non-polar liquid stream – a

hydrotreated stream (118) is obtained. The hydrotreated stream (118) is combined with hydrogen rich gas (130,132) and a recycle (120) and directed as a hydrodearomatization feed stream (119) to a hydrodearomatization (HDA) step to provide a hydrodearomatized stream (121) comprising non-aromatic compounds which are more reactive than the corresponding aromatic compounds. Since the recycle consists of hydrocarbons having passed hydrodearomatization (HDA), the recycle (120) may also, depending on the extent of hydrodearomatization, be directed to be combined with the hydrodearomatized stream (121). This hydrodearomatized stream (121) is directed to hydrocracking (HC) to provide a hydrocracked stream (122) to which wash water (124) is optionally added prior to separation in a polar fraction (126), a gas fraction (128) and a non-polar fraction (136) which is sent to fractionation (FRAC) to provide a vapor fraction (138), a product fraction (140) and a high boiling fraction (144) and optionally additional streams. One amount of the high boiling fraction (144) is directed to a heated stripper (HST) also receiving a stream of stripping medium (146) such as steam, while the remainder of the high boiling fraction is directed as recycle (120) to be combined with the hydrotreated stream (118). The vapor outlet (142) of the heated stripper (HST) is directed to the fractionator, and the liquid outlet (148) is directed to purge, optionally with an amount recycled (150) to the heated stripper (HST). This purge stream will be rich in the very highest boiling fractions, which will encompass an increased concentration of polycyclic compounds, such as non-aromatic polycyclic compounds as well as any non-converted PNA and HPNA.

[0059] The recycled stream (120) comprises at least 50 weight% of the high boiling fraction, such as 80 weight% or 90 weight% meaning that only a limited amount is directed to the heated stripper (HST), and from there to purge. This step separates the HPNA rich stream from a lower boiling fraction of the bottom stream. The lower boiling fraction is then either directed to the fractionation step or to the hydrodearomatization step. The stripping step involves directing heat to a stream of the stripping step, facilitating the separation process.

Fig.2

[0060] Figure 2 shows another embodiment of a process layout for producing a hydrocarbon product (240) from a hydrocarbonaceous stream (202). The

hydrocarbonaceous stream (202) is derived from a thermochemical decomposition of a solid material (not shown). The solid material may comprise one or more compounds taken from the group comprising lignin, cellulose, hemicellulose, lipids, proteins, and artificial polymers.

[0061] The hydrocarbonaceous stream (202) is combined with make-up hydrogen (216) and a gaseous recycle stream (212) and directed to hydrodenitrification and other reactions in the first stage reactors HDT to provide a reduced content of organically bound nitrogen by contact with a material catalytically active in hydrotreatment under active hydrotreatment conditions to provide a hydrotreated hydrocarbon stream (204).

[0062] This step reduces the potential catalyst passivation of catalytically active material by ammonia and organic nitrogen in downstream reactors. In this way, the method integrates several steps to efficiently produce a hydrocarbon product from a hydrocarbonaceous stream derived from various types of solid materials.

[0063] The hydrotreated hydrocarbon stream (204), is washed by addition of water (206), and separation in a high pressure separator (HPS), from which a gaseous stream, which is split in a gaseous recycle stream (212) and a gaseous purge stream (214), a polar liquid stream (215) and a non-polar liquid stream – a hydrotreated stream (218) is obtained. The hydrotreated stream (218) is combined with a hydrocracked product stream (221) comprising a hydrogen rich gas phase is directed to a hydrodearomatization (HDA) step to provide a hydrodearomatized combined stream (222) comprising non-aromatic compounds which are more reactive than the corresponding aromatic compounds. To this hydrodearomatized combined stream (222) water (224) is optionally added prior to high pressure separation (HPS) in a polar fraction (226), a gas fraction (228) and a non-polar fraction (236) which is sent to fractionation (FRAC) to provide a vapor fraction (238), a product fraction (240) and a high boiling fraction (244) and optionally additional streams.

[0064] One amount of the high boiling fraction (244) is directed to a heated stripper (HST) also receiving a stream of stripping medium (246) such as steam, while the remainder of the high boiling fraction is directed as recycle (220). The vapor outlet (242) of the heated stripper (HST) is directed to the fractionator, and the

liquid outlet (248) is directed to purge, optionally with an amount recycled (250) to the heated stripper (HST). This purge stream will be rich in the very highest boiling fractions, which will encompass an increased concentration of polycyclic compounds, such as non-aromatic polycyclic compounds as well as any non-converted PNA and HPNA. The recycle (220) and a hydrogen rich gas (230,232) is directed to a hydrocracking (HC) step to provide the hydrocracked product stream (221).

[0065] In this embodiment the content of aromatics in the recycle stream (220) as well as in the product (240) will be moderate, since the entire stream (236) directed to the fractionator (FRAC) will have undergone the hydrodearomatization step (HDA) and in addition an amount of HPNA precursors, including PNA and non-aromatic polycyclic structures will be removed in the liquid outlet (248) from stripper, which is purged. Therefore, the potential for formation of HPNA in hydrocracking will be low, in spite of a high potential for HPNA formation in the hydrotreated stream (218).

Fig.3

[0066] Figure 3 shows another embodiment of a process layout for producing a hydrocarbon product (340) from a hydrocarbonaceous stream (302). The hydrocarbonaceous stream (302) is derived from a thermochemical decomposition of a solid material (not shown). The solid material may comprise one or more compounds taken from the group comprising lignin, cellulose, hemicellulose, lipids, proteins, and artificial polymers.

[0067] The hydrocarbonaceous stream (302) is combined with make-up hydrogen (316) and a gaseous recycle stream (312) and directed to hydrodenitrification and other reactions in the first stage reactors HDT to provide a reduced content of organically bound nitrogen by contact with a material catalytically active in hydrotreatment under active hydrotreatment conditions to provide a hydrotreated hydrocarbon stream (304).

[0068] This step reduces the potential catalyst passivation of catalytically active material by ammonia and organic nitrogen in downstream reactors. In this way, the method integrates several steps to efficiently produce a hydrocarbon product from a hydrocarbonaceous stream derived from various types of solid materials.

- [0069] The hydrotreated hydrocarbon stream (304), is washed by addition of water (306), and separation in a high pressure separator (HPS), from which a gaseous stream, which is split in a gaseous recycle stream (312) and a gaseous purge stream (314), a polar liquid stream (315) and a non-polar liquid stream – a hydrotreated stream (318) is obtained.
- [0070] The hydrotreated stream (318) is in this embodiment sent to fractionation (FRAC) to provide a vapor fraction (338), a product fraction (340) and a high boiling fraction (344) and optionally additional streams. This will provide a product fraction (340) with a higher aromatic content than that of Fig.1 and Fig.2.
- [0071] One amount of the high boiling fraction (344) is directed to a heated stripper (HST) also receiving a stream of stripping medium (346) such as steam, while the remainder of the high boiling fraction is directed as recycle (320). The vapor outlet (342) of the heated stripper (HST) is directed to the fractionator (FRAC), and the liquid outlet (348) is directed to purge, optionally with an amount recycled (350) to the heated stripper (HST). This purge stream will encompass an increased concentration of the very highest boiling fractions, including the polycyclic compounds, such as PNA and HPNA, as well as the equivalent non-aromatic polycyclic compounds.
- [0072] The remainder of the high boiling fraction (320) is together with hydrogen rich gas (330,332) directed to a hydrodearomatization (HDA) step to provide a hydrodearomatized stream (321) comprising non-aromatic compounds which are more reactive than the corresponding aromatic compounds. The hydrodearomatized stream (321) is including a hydrogen rich gas phase directed to hydrocracking (HC) to provide a hydrocracked stream (322), to which water (324) is optionally added prior to separation in a polar fraction (326), a gas fraction (328) and a non-polar fraction which is combined with the hydrotreated stream (318) as fractionator feed stream (336) and is sent to fractionation (FRAC) together with the hydrotreated stream (318).
- [0073] In this embodiment the content of aromatics in the recycle stream (320) will be high, since only the recycled heavy stream will have undergone the hydrodearomatization step (HDA) so even though an amount of HPNA precursors, including PNA and non-aromatic polycyclic structures will be removed

in the liquid outlet (348) from the stripper the potential for formation of HPNA in hydrocracking may have a potential for HPNA formation in the hydrotreated stream (318), and the conditions for hydrocracking must be considered.

Fig.4

[0074] Figure 4 shows another embodiment of a process layout for producing a hydrocarbon product (440) from a hydrocarbonaceous stream (402). The hydrocarbonaceous stream (402) is derived from a thermochemical decomposition of a solid material (not shown). The solid material may comprise one or more compounds taken from the group comprising lignin, cellulose, hemicellulose, lipids, proteins, and artificial polymers, and may be sewage sludge or an industrial waste dispersion.

[0075] The hydrocarbonaceous stream (402) is combined with make-up hydrogen (416) and a gaseous recycle stream (412) and directed to hydrodenitrification and other reactions in one or more first stage reactor (HDT) to provide a reduced content of organically bound nitrogen by contact with a material catalytically active in hydrotreatment under active hydrotreatment conditions to provide a hydrotreated hydrocarbon stream (404).

[0076] This step reduces the potential catalyst passivation of catalytically active material by ammonia and organic nitrogen in downstream reactors. In this way, the method integrates several steps to efficiently produce a hydrocarbon product from a hydrocarbonaceous stream derived from various types of solid materials.

[0077] The hydrotreated hydrocarbon stream (404), is washed by addition of water (406), and separation in a high pressure separator (HPS), from which a gaseous stream, which is split in a gaseous recycle stream (412) and a gaseous purge stream (414), a polar liquid stream (415) and a non-polar liquid stream – a hydrotreated stream (418) is obtained.

[0078] In this embodiment the hydrotreated stream (418) and a purified hydrodearomatized stream (442) are both sent to fractionation (FRAC) to provide a vapor fraction (438), a product fraction (440) a high boiling fraction (444) and optionally additional streams. This will provide an aromatic product fraction (440).

[0079] From the high boiling fraction (444) a high boiling purge (452) is optionally withdrawn, and the remainder of the high boiling fraction (420) is together with make up hydrogen (432) and recycled hydrogen rich gas (430) directed to a hydrodearomatization (HDA) step to provide a hydrodearomatized stream (421) comprising non-aromatic compounds which are more reactive than the corresponding aromatic compounds. The hydrodearomatized stream (421) is directed to hydrocracking (HC) to provide a hydrocracked stream (422), to which water (424) is optionally added prior to being directed to a separator (HPS) separating this stream in a polar fraction (426), a gas fraction (428) and a non-polar fraction (436) sent to a product stripper (STRIP) which also receives a stripping medium (437). The vapor fraction stream (439) from the product stripper (STRIP), is rich in light gases and commonly purged, but may contain combustible gases and be directed to separation or purification for use in other positions in the process,. The liquid fraction stream (441) from the product stripper is directed to a heated stripper (HST) also receiving a stream of stripping medium (446) such as steam. The vapor outlet (442) of the heated stripper (HST) is directed to the product stripper (STRIP) or the fractionator (FRAC), and the liquid outlet (448) is directed to purge, optionally with an amount recycled (not shown) to the heated stripper (HST). The purge stream will be rich in the very highest boiling fractions, which will be encompass an increased concentration of polycyclic compounds, such as PNA and HPNA, as well as non-aromatic polycyclic compounds.

[0080] In this embodiment the content of aromatics in the recycle stream (420) will be high, since only the recycled heavy stream will have undergone the hydrodearomatization step (HDA), but all HPNA and HPNA precursors will be removed in the liquid outlet (448), which makes this embodiment beneficial if the HPNA potential is high.

[0081] The figures above illustrate key principles of the disclosed process, but the specific implementation may differ. This includes the specific configuration of hydrogen addition, process heating and separation, as well as other elements known to the skilled person. In addition, individual process elements such as pumps, compressor and heat exchangers may be required and implemented by the skilled person. Furthermore, the illustration shows a single output product

(140, 240, 340 and 440) which commonly would be fractionated in two or more of naphtha, aviation fuel and diesel fuel. If such a product stream contains aromatics above limits, it may also be split in fractions directed to hydrodearomatization by recycle or downstream fractionation.

[0082] Finally for the embodiments of Fig.1 and Fig.2 where the entire hydrotreated stream (118, 218) is directed to hydrodearomatization (HDA) and Fig.3 and Fig.4 where the entire hydrotreated stream (318, 418) is directed to fractionation (FRAC), alternative configurations also exist, in which this stream may be split, either in streams with identical composition or in a hot gas liquid separator, and one amount is directed to the fractionator (FRAC) and another to hydrodearomatization (HDA), which will result in a higher product concentration of aromatics, but in a smaller hydrodearomatization reactor, and thus lower capital cost and operational cost. Such a split may even be configured for dynamic operation to match changes in requirements due to feedstock or product mix.

[0083] As HPNA may not constitute a problem in large bore engines, such as marine engines, the process may also be designed to direct an amount of the high boiling fraction (144, 244, 344, 444) to be combined with the purge stream (148, 248, 348, 448) for use as marine fuel, or alternatively to configure the heated stripper to direct a higher fraction to purge.

Description of Embodiments

[0084] A broad aspect of the present disclosure relates to a method for production of a hydrocarbon product from a hydrocarbonaceous stream derived from a thermochemical decomposition of a solid renewable material, said method involving the following steps

- (a) directing said hydrocarbonaceous stream to a hydrotreatment step to provide a hydrotreated stream,
- (b) directing at least 80 wt% of the T90 to T95 fraction of said hydrotreated stream to a hydrodearomatization step to provide a hydrodearomatized stream,
- (c) directing a hydrocracking feed stream comprising at least an amount of the hydrodearomatized stream to a hydrocracking step to provide a hydrocracked stream.

(d) fractionating a fractionation feedstream comprising one or both of the hydrodearomatized and the hydrocracked stream to provide said hydrocarbon product and a high boiling fraction comprising at least 80 wt% of the T90 to T95 fraction of said fractionation feedstream, characterized in step d involving a substep of withdrawing a stream having an average boiling point above the high boiling stream and directing from 1% to 50% as a heavy polynuclear aromatics rich stream, wherein the heavy polynuclear aromatics rich stream has a higher concentration by mass of heavy polynuclear aromatics than said high boiling stream.

[0085] This has the associated benefit of treating a feedstock having propensity for HPNA formation by hydrotreatment, hydrodearomatization and hydrocracking thus reducing the risk of downstream catalyst passivation by removing heteroatoms and increasing the reactivity of the fraction, by hydrodearomatization of at least a heavy fraction and reducing the propensity for formation of HPNA, by hydrocracking and ring opening of at least a portion of the hydrodearomatized fraction and fractionating one of the reacted streams to provide a possibility for recycling the majority of the heaviest stream for further reaction, while the highest boiling fraction may be withdrawn to purge. The hydrocracking feed stream may comprise the hydrodearomatized stream in its entirety, an amount of the hydrodearomatized stream have substantially the same composition or a stream fractionated from the hydrodearomatized stream. The heavy polynuclear aromatics rich stream may be withdrawn from the purge stream and the higher concentration by mass of heavy polynuclear aromatics than said high boiling stream may be enabled by use of selective adsorbents, separation by specific stripping configurations, or liquid extraction. A purge stream shall be understood as a stream withdrawn and not directed in untreated manner to any of the steps a-d. The purge stream may be combusted, undergo chemical reaction or be collected as chemical waste.

[0086] A second aspect of the present disclosure involves a stripping step receiving a stripper feed and a stripping medium feed, and directing a stripper vapor to said fractionator and an amount of a stripped liquid to purge, wherein the mass flow of the amount of a stripped liquid directed to purge is from 1% to 50% of the mass flow of the stripper feed and wherein the stripper feed

comprises either at least 50 wt% of said hydrocracked stream or a stream of said high boiling fraction.

- [0087] This has the associated benefit of such a stripping step being an effective separation of the high boiling fraction rich in polynuclear aromatics (PNA) directed to purge, to minimize the formation of heavy polynuclear aromatics (HPNA) as a side reaction during hydrocracking, while allowing additional ring opening and conversion to lower boiling compounds.
- [0088] A third aspect of the present disclosure relates to a method according to the second aspect wherein the fractionation feedstream is directed to a stripper, the stripper vapor is directed to a fractionator and stripped liquid is directed as the heavy polynuclear aromatics rich stream.
- [0089] This has the associated benefit of a stripping step being an efficient method for selective separation of heavy polynuclear aromatics (HPNA) from other high boiling streams, especially if a high amount of HPNA is present.
- [0090] A fourth aspect of the present disclosure relates to a method according to the second aspect wherein the fractionation feedstream is directed to a fractionator and a bottom stream from the fractionator is directed to a stripping step, separating a heavy polynuclear aromatics rich stream from a lower boiling fraction of the bottom stream, and wherein the lower boiling stream is either directed to the fractionation step or to the hydrodearomatization step.
- [0091] This has the associated benefit of a stripping step being an efficient way of avoiding recycle of HPNA.
- [0092] A fifth aspect of the present disclosure relates to a method according to the third or fourth aspect in which the stripping step involves directing heat to a stream of the stripping step,
- [0093] This has the associated benefit of heating the stripping process, such that stripping occurs close to or above the bubble point of the high boiling fraction, facilitating efficient separation of HPNA from other high boiling fractions.
- [0094] A sixth aspect of the present disclosure relates to a method according to the any aspect above wherein the hydrotreated stream has a nitrogen content below

200 ppmwt, 100 ppmwt or 50 ppmwt and optionally above 100 ppbwt, 1 ppmwt or 10 ppmwt of organically bound nitrogen.

[0095] This has the associated benefit of minimizing catalyst passivation, which otherwise may be limiting the hydrodearomatization and hydrocracking of the hydrocarbonaceous stream. The same step may also convert oxygenates and sulfur compounds, or such conversion may take place in separate hydrotreatment steps. Commonly the product stream of hydrodenitrification will be separated in a liquid phase and a gas phase, and only the liquid phase will be transferred to further method steps. The effect of the nitrogen content being below 200 ppmwt, 100 ppmwt or 50 ppmwt is a reduced tendency to passivation of the downstream hydrodearomatization and hydrocracking catalysts, and the effect of optionally not fully removing nitrogen is that the remaining nitrogen may be removed by reaction over the downstream catalysts.

[0096] A seventh aspect of the present disclosure relates to a method according to the any aspect above wherein step c involves directing a stream from a fractionator comprising at least said high boiling fraction to said hydrocracking step and wherein the fractionator has received said hydrodearomatized stream.

[0097] This has the associated benefit of enabling recycle of a stream with moderate aromatics content to hydrocracking, which allows milder hydrocracking conditions and thus reduced yield loss while avoiding extensive formation of HPNA.

[0098] An eighth aspect of the present disclosure relates to a method according to the any aspect above wherein step c involves directing a stream from the fractionator comprising at least said high boiling fraction to said hydrodearomatization step and directing the hydrodearomatized stream to said hydrocracking step.

[0099] This has the associated benefit of enabling recycle of a stream with high aromatics content to hydrocracking, while avoiding extensive formation of HPNA.

[0100] A ninth aspect of the present disclosure relates to a method according to the any aspect above wherein step d involves directing the hydrocracked stream as well as the hydrotreated stream to said fractionating step and wherein the hydrodearomatization step receives a stream comprising at least said high boiling fraction.

- [0101] This has the associated benefit of reducing the amount directed to hydrodearomatization and hydrocracking, which reduces the required catalyst volumes as well as the yield loss from hydrocracking low boiling hydrocarbons. The hydrocarbon product may in this case comprise a elevated amounts of aromatics.
- [0102] A tenth aspect of the present disclosure relates to a method according to any aspect above wherein at least an amount of T95+ fraction from a fractionation section and the hydrocracked stream as well as the hydrotreated stream are directed to said fractionating step.
- [0103] This has the associated benefit using a separation section, comprising one or more of strippers, separators and a fractionator, to separate a first useful product fraction requiring little hydrogen consumption from other fractions requiring more hydrogen consumption. The first useful product fraction may be a high boiling fraction useful as a marine fuel, whereas the other fractions may be aviation fuel or diesel, having stricter regulatory and trade standards.
- [0104] An eleventh aspect of the present disclosure relates to a method according to the any aspect above, further comprising a step of directing a solid material comprising one or more compounds taken from the group comprising lignin, cellulose, hemicellulose, lipids, proteins and artificial polymers to a thermochemical decomposition process, providing said hydrocarbonaceous stream.
- [0105] This has the associated benefit of such solid materials having the potential to produce hydrocarbonaceous streams with a high amount of polyaromatics, due to the dominance of polyaromatic structures in the solid material.
- [0106] A further aspect relates to a process plant for carrying out a process according to any claim above.

Examples

- [0107] A feed stream from thermochemical decomposition of sewage sludge was analyzed and treatment of the stream was simulated by a combination of pilot scale experiments and calculations. This feed contains 83 wt% C, 9 wt% H, 8

wt% O and 681 ppmwt N, as well as minor impurities, which are not considered here.

[0108] The compositions of streams according to Fig.1 and Fig.3 are illustrated in Table 1 and Table 2, where all values reported relate to the C5+ fraction only, i.e. the fractions which will be liquid at ambient conditions.

[0109] Table 1 shows the performance of a process as shown in Fig.1, where all of the hydrotreated stream is directed to hydrodearomatization and further to hydrocracking. The liquid phase of hydrotreated stream contains 5 ppmwt N and thus may be considered pure hydrocarbon. The process also involves recycle of a heavy product for multi-pass hydrocracking. It is seen that (the C5+ fraction of) the hydrotreated stream has a moderate H:C ratio of 1.59 prior to combination with the recycled high boiling fraction. The process results in a distillate product yield of 73 ton/h, with a content of 10 wt% aromatics.

[0110] Table 2 shows the performance of a process as shown in Fig.3, where the hydrotreated stream, in which the liquid phase which is similar to Fig.1, is directed to fractionation, and only the high boiling fraction is directed to hydrodearomatization and further to hydrocracking. The stream directed to hydrodearomatization has a very low H:C ratio of 1.48, but still allows hydrodearomatization and hydrocracking, with little risk of HPNA build-up due to the purge in stream 348. This process results in a yield of 80 ton/h, with a content of 48 wt% aromatics, which may be acceptable in some transportation fuels. The process requires significantly smaller hydrodearomatization and hydrocracking catalyst volumes than that of Fig.1, as smaller streams are treated.

[0111] The process may be adjusted further to the requirements for the product and the nature of the feedstock. If the feedstock contains a higher amount of high boiling product, the amount of recycle may be increased, and if the amount of aromatics in the product according to Fig.3 is too high, a portion of the hydrotreated stream (318) may be combined with the recycle, to arrive at a process containing elements of both processes.

Table 1

Stream		102	118	119	121	122	140	120	148
	ton/h	100	86	99	96	88	73	13	2
H:C		1.29	1.59	1.62	1.79	1.94	1.97	1.79	1.79
N	wt ppm	681	5	4	2	1	1	1	1
Aromatics	wt%								
Total aromatics			57	51	19	10	10	10	10
Simulated distillation									
IBP	°C	162	113	113	94	57	57	373	386
T5	°C	204	149	153	138	108	105	391	424
T50	°C	369	312	327	290	216	198	506	544
T90	°C	577	493	545	523	479	309	644	660
FBP	°C	738	715	731	731	731	375	731	731

Table 2

Stream		302	318	321	322	340	320	348
Flow	ton/h	100	86	36	32	80	37	2
H:C		1.29	1.59	1.71	1.92	1.78	1.48	1.48
N	wt ppm	681	5	1	1	1	7	7
Aromatics	wt%							
Total aromatics			57.2	12.8	6.4	48	34.3	34.3
Simulated distillation								
IBP	°C	162	113	94	57	57	373	407
T5	°C	204	149	138	108	105	391	458
T50	°C	369	312	290	216	198	506	563
T90	°C	577	493	523	479	309	644	669
FBP	°C	738	715	731	731	375	731	731

Claims

- [Claim 1] A method for producing a hydrocarbon product from a hydrocarbonaceous stream derived from a thermochemical decomposition of a solid renewable material, said method involving the following steps
- directing said hydrocarbonaceous stream to a hydrotreatment step to provide a hydrotreated stream,
 - directing at least 80 wt% of the T90 to T95 fraction of said hydrotreated stream to a hydrodearomatization step to provide a hydrodearomatized stream,
 - directing a hydrocracking feed stream comprising at least an amount of the hydrodearomatized stream to a hydrocracking step to provide a hydrocracked stream.
 - fractionating a fractionation feedstream comprising one or both of the hydrodearomatized and the hydrocracked stream, to provide said hydrocarbon product and a high boiling fraction comprising at least 80 wt% of the T90 to T95 fraction of said fractionator feedstream characterized in step d involving a substep of withdrawing a stream having an average boiling point above the high boiling stream and directing from 1% to 50% as a heavy polynuclear aromatics rich stream, wherein the heavy polynuclear aromatics rich stream has a higher concentration by mass of heavy polynuclear aromatics than said high boiling stream.
- [Claim 2] A method according to claim 1, involving a stripping step receiving a stripper feed and a stripping medium feed, and directing a stripper vapor to said fractionator and an amount of a stripped liquid to purge, wherein the mass flow of the amount of the stripped liquid directed to purge is from 1% to 50% of the mass flow of the stripper feed and wherein the stripper feed comprises either at least 50 wt% of said hydrocracked stream or a stream of said high boiling fraction.
- [Claim 3] A method according to claim 2 wherein the fractionation feedstream is directed to said stripper, the stripper vapor is directed to a fractionator and stripped liquid is directed as the heavy polynuclear aromatics rich stream.

- [Claim 4] A method according to claim 2 wherein the fractionation feedstream is directed to a fractionator and a bottom stream from the fractionator is directed to a stripping step, separating a heavy polynuclear aromatics rich stream from a lower boiling fraction of the bottom stream, and wherein the lower boiling stream is either directed to the fractionation step or to the hydrodearomatization step.
- [Claim 5] A method according to claim 3 or 4 in which the stripping step involves directing heat to a stream of the stripping step.
- [Claim 6] A method according to any claim above wherein the hydrotreated stream has a nitrogen content below 200 ppmwt, 100 ppmwt or 50 ppmwt and optionally above 100 ppbwt, 1 ppmwt or 10 ppmwt of organically bound nitrogen.
- [Claim 7] A method according to any claim above wherein step c involves directing a stream from a fractionator comprising at least said high boiling fraction to said hydrocracking step and wherein the fractionator has received said hydrodearomatized stream.
- [Claim 8] A method according to any claim above wherein step c involves directing a stream from the fractionator comprising at least said high boiling fraction to said hydrodearomatization step and directing the hydrodearomatized stream to said hydrocracking step.
- [Claim 9] A method according to any claim above wherein step d involves directing the hydrocracked stream as well as the hydrotreated stream to said fractionating step and wherein the hydrodearomatization step receives a stream comprising at least said high boiling fraction.
- [Claim 10] A method according to any claim above in combination with claim 6 wherein at least an amount of T95+ fraction from a fractionation section and the hydrocracked stream as well as the hydrotreated stream are directed to said fractionating step.
- [Claim 11] A method according to any claim above, further comprising a step of directing a solid material comprising one or more compounds taken from the group comprising lignin, cellulose, hemicellulose, lipids, proteins and artificial polymers to a thermochemical decomposition process, providing said hydrocarbonaceous stream.

[Claim 12] A process plant for carrying out a process according to any claim above.