

HEAVY DISTILLATE COMPOSITION

FIELD

[0001] A heavy distillate composition is provided, along with systems and methods for producing such a composition.

5 BACKGROUND OF THE INVENTION

[0002] The aviation industry is looking for increasingly sustainable sources of jet fuel to lower the carbon intensity of the fuel consumed during flight. While the aviation industry today contributes 2-3% of global CO₂ emissions, this is expected to increase with the anticipated growth of the aviation sector over the next 30 years. There are a number of sustainable aviation fuel pathways that have been approved for use in commercial aviation.

[0003] Increased production of sustainable diesel fuel is also of general interest. Some renewable diesel products are already commercially available.

[0004] Renewable jet production is typically a multi-step process: either single stage or two stage. In a first step, triglycerides, FAME, FFA are hydrotreated with conventional hydrotreating catalysts under typical hydrotreating conditions to convert fatty acid chains to n-paraffins. The resulting n-paraffins are then exposed to a combination of dewaxing and cracking conditions (either as a single step or a plurality of steps) to form a hydroprocessed effluent. The hydroprocessed effluent is then fractionated to produce naphtha, jet, and diesel boiling range fractions.

[0005] Because the goal of conventional processes for forming renewable jet is to make a jet boiling range product, the cracking and/or dewaxing conditions are selected to form jet boiling range molecules. A fractionation is used to separate out components boiling below and above the jet boiling range. Typically, the components boiling above the jet boiling range correspond in part to unconverted n-paraffins.

[0006] U.S. Patent 8,193,399 describes a system and method for converting a bio-derived feed to form a jet and a diesel fraction. The bio-derived feed is introduced into an initial deoxygenation (hydrotreatment) stage, along with a sufficient amount of a recycled product stream to improve hydrogen solubility, so that low pressure operation can be performed. After deoxygenation, the deoxygenated liquid effluent is exposed to both isomerization and hydrocracking conditions. Both a diesel product and a jet product are the separated from the

isomerized and hydrocracked effluent. A portion of one or both of these products is used to provide the recycle stream.

[0007] U.S. Patent 8,314,274 describe methods for converting a bio-derived feed to form a jet and a diesel fraction. After hydrotreatment to remove oxygen, the feed is hydroisomerized and hydrocracked. The hydrocracking and hydroisomerization can be performed as a single step if an appropriate catalyst is selected. Otherwise, separate cracking and hydroisomerization steps are performed. The process is described as using recycle to allow for production of diesel boiling range components that correspond to C₁₆ or smaller compounds, in order to improve the cold flow properties of the resulting diesel fraction.

10 [0008] U.S. Patent 8,431,756 describes processing a bio-derived feed that still includes a substantial oxygen content with a dewaxing catalyst in order to deoxygenate and/or isomerize the feed.

[0009] U.S. Patents 8,674,160 and 10,000,712 describe general hydroprocessing of a wide range of bio-derived feedstocks to form diesel fuels with improved cold flow properties.

15 [0010] U.S. Patent 8,729,330 describes exposing mixtures of a bio-derived feed having substantial oxygen content and a mineral feed to a dewaxing / isomerization catalyst.

[0011] U.S. Patent 9,617,479 describes hydrodeoxygenation of a wide range of triglyceride-containing feeds under conditions that preserve oxygen and/or olefin content in the feed during hydrodeoxygenation. This can allow for recovery of increased amounts of propylene versus propane when processing triglycerides. The resulting hydrodeoxygenated product can undergo further hydroprocessing.

[0012] U.S. Patent 10,053,639 describes producing both a jet fuel product and a diesel fuel product from a feedstock. The feedstock can optionally include a bio-derived portion.

25 [0013] U.S. Patent Application Publication 2008/0066374 describes processing of bio-derived feeds over catalysts including both a catalytic metal function and an acidic function to form diesel fuels. Several examples of processing of soybean oil are provided.

[0014] International Publication WO 2021/099343 describes processing bio-derived feeds containing C₁₂ to C₂₄ hydrocarbons to form a renewable hydrocarbon composition for use as a jet fuel blending component. The feed is hydrodeoxygenated and hydroisomerized. The resulting hydroprocessed effluent is then typically fractionated to separate heavier (i.e., diesel) boiling range components from a jet boiling range fraction. The hydrocarbon composition is described as having an average carbon number of 14.3 to 15.1. This is apparently achieved by

having more than 60 wt% of the hydrocarbon composition correspond to C₁₄ to C₁₇ hydrocarbons.

SUMMARY OF THE INVENTION

[0015] In an aspect, a distillate boiling range composition is provided. The composition
5 can include 80 wt% or more of isoparaffins. The composition can further include 15 wt% or less of n-paraffins. The composition can further include a T10 distillation point of 290°C or more and/or a T90 distillation point of 325°C or less. Additionally, the composition can include at least one of i) a total aromatics content of 0.1 wt% or more, and ii) a one-ring aromatics content of 0.07 wt% or more. Optionally, a difference between the T90 distillation point and
10 the T10 distillation point can be 20°C or less. Optionally, the composition can have a cloud point of -20°C or less (such as -20°C to -80°C).

[0016] In another aspect, such a distillate boiling range composition can be blended with one or more distillate fractions, one or more resid fractions, or a combination thereof to form a blended composition. In such an aspect, the distillate boiling range composition can correspond
15 to 1.0 wt% to 99 wt% of the blended composition.

BRIEF DESCRIPTION OF THE DRAWING

[0017] The Figure shows an example of a reaction system for producing a distillate boiling range composition.

DETAILED DESCRIPTION OF THE INVENTION

20 Overview

[0018] In various aspects, a distillate boiling range composition is provided with an unexpected distribution of carbon chain lengths for the hydrocarbons in the composition. The composition corresponds to a distillate boiling range composition with a relatively narrow boiling range. The composition can have a T10 distillation point of 290°C or more while also
25 having a T90 distillation point of 325°C or less, or 320°C or less, or 315°C or less, or 310°C or less. The composition can also include a minor portion of aromatics, such as a total aromatics content of roughly 0.1 wt% to 4.0 wt%. Additionally, this narrow boiling range composition can have unexpectedly beneficial cold flow properties.

[0019] This narrow boiling range can be achieved by starting with a glyceride-based feed (such as a feed based on triglycerides or fatty acid alkyl esters) and then exposing the feed to hydrotreating conditions followed by deep dewaxing conditions using an isomerization catalyst. The resulting isomerized product can then be fractionated to form a jet boiling range
5 fraction and a remaining portion corresponding to a distillate boiling range composition. After the fractionation, the jet boiling range fraction includes the majority of the compounds with boiling points below 290°C, so that the distillate boiling range fraction has a T90 of 290°C or higher. Due to the nature of glyceride-based feeds, substantially all of the carbon chains in the feed correspond to C₂₂ chains or smaller. Since hydroprocessing does not typically cause
10 oligomerization, the upper end of the boiling range is limited based on the nature of the feed. As a result, the distillate boiling range fraction that remains after forming the jet boiling range fraction can have a relatively narrow boiling range.

[0020] Conventionally, renewable jet fractions are formed by hydrotreating of glyceride-based feeds followed by some type of dewaxing. Some type of separation is then used to form
15 a renewable jet fraction. To improve the yield of jet boiling range compounds, the severity of the dewaxing process is set to be somewhat mild, so that cracking of jet compounds into naphtha or light ends is reduced or minimized. Recycle is then typically used to allow for additional formation of jet boiling range compounds. Based on this type of reaction scheme, any remaining higher boiling portion after this separation typically includes a large portion of
20 n-paraffins that were not converted during the dewaxing process.

[0021] In contrast to conventional processes, in various aspects the dewaxing conditions can be selected so that substantially all of the n-paraffins in the feed are converted into isoparaffins. This can correspond to having 15 vol% or less of n-paraffins in the resulting distillate composition, or 10 vol% or less, or 5.0 vol% or less, such as down to 1.0 vol% or
25 possibly still less. By using a catalyst with high selectivity for isomerization, this deep isomerization can be achieved while reducing or minimizing overcracking of jet boiling range compounds into naphtha and/or light ends. Thus, both the jet boiling range fraction and the distillate boiling range fraction formed after separation can contain a reduced or minimized content of n-paraffins.

[0022] In some aspects, the hydrocarbon composition can be formed by processing a bio-derived feed that contains a high proportion of C₁₇₊ carbon chains. During processing of the bio-derived feedstock, the feedstock can be exposed to hydrotreating conditions (for deoxygenation) followed by catalytic dewaxing. The catalytic dewaxing conditions can be
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selected to provide sufficient severity for substantially complete conversion of n-paraffins to isoparaffins while still reducing or minimizing cracking of paraffins. An example of a dewaxing catalyst that can primarily provide isomerization rather than cracking is a ZSM-48 based catalyst. After dewaxing, the dewaxed effluent can be separated to form at least a jet boiling range fraction and the distillate boiling range composition.

[0023] In some aspects, the method for forming the distillate boiling range composition can also produce a jet boiling range composition having an unexpected distribution of carbon chain lengths for the hydrocarbons and paraffins in the composition. The jet boiling range composition can include 40 wt% or more of hydrocarbons and/or paraffins that have carbon chain lengths of 17 carbons or 18 carbons. In other words, the jet boiling range composition contains 40 wt% or more of $C_{17} - C_{18}$ hydrocarbons, or 50 wt% or more, or 60 wt% or more, or 70 wt% or more, such as up to 85 wt% or possibly still higher. Additionally or alternately, the jet boiling range composition can contain 45 wt% or less of $C_{14} - C_{17}$ hydrocarbons and/or paraffins, or 40 wt% or less, or 35 wt% or less, such as down to 25 wt% or possibly still lower.

This unexpected distribution of carbon chain lengths in a jet boiling range composition can be achieved for a composition that has a freeze point of -40°C or lower and a flash point of 38°C or higher. Preferably, the jet boiling range composition can also have a T10 distillation point of 205°C or less (such as down to 150°C) and a final boiling point of 300°C or less. Preferably, the jet boiling range composition can have a density at 15°C of 765 kg/m^3 or more, or 768 kg/m^3 or more, or 770 kg/m^3 or more, such as up to 775 kg/m^3 or possibly still higher. This unexpected combination of properties is achieved in part based on the fact that substantially all of the paraffins in the hydrocarbon composition correspond to isoparaffins, with n-paraffins corresponding to 10 wt% or less of the C_{12+} hydrocarbons in the composition (relative to the weight of the C_{12+} hydrocarbons), or 5.0 wt% or less of the C_{14+} hydrocarbons in the composition (relative to the weight of the C_{14+} hydrocarbons), or 5.0 wt% or less of the C_{12+} hydrocarbons in the composition (relative to the weight of the C_{12+} hydrocarbons), or 3.0 wt% or less of the of the C_{14+} hydrocarbons in the composition (relative to the weight of the C_{14+} hydrocarbons), such as down to having substantially no content of C_{12+} or C_{14+} n-paraffins (0.1 wt% or less). In some aspects, the hydrocarbon composition can contain 2.5 wt% or less of C_{19+} hydrocarbons, or 1.5 wt% or less, or 1.0 wt% or less, or 0.5 wt% or less, such as down to having substantially no content of C_{19+} hydrocarbons (0.1 wt% or less).

DEFINITIONS

[0024] The cloud point of a fraction can be determined according to ASTM D5773. The freeze point of a fraction (such as a feed or product) can be determined according to ASTM D5972. The flash point of a fraction can be determined according to ASTM D6450. The cold filter plugging point (CFPP) of a fraction can be determined according to ASTM D6371. The pour point of a fraction can be determined according to ASTM D5950. The density of a fraction can be determined according to ASTM D4052. The kinematic viscosity of a fraction (such as kinematic viscosity at 40°C) can be determined according to ASTM D445.

[0025] In this discussion, “Tx” refers to the temperature at which a weight fraction “x” of a sample can be boiled or distilled. For example, if 40 wt% of a sample has a boiling point of 350°F or less, the sample can be described as having a T40 distillation point of 350°F. In this discussion, boiling points can be determined by a convenient method based on the boiling range of the sample. This can correspond to ASTM D86. In the event that ASTM D86 cannot be performed on a sample due to the nature of the sample, ASTM D2887 may be used instead. One convenient way of specifying a boiling range for a fraction can be to specify a T10 distillation point and a T90 distillation point for the fraction.

[0026] In this discussion, a distillate boiling range fraction corresponds to a fraction having T10 distillation point of 170°C or more and a T90 distillation point of 500°C or less. A fraction having a T90 distillation point of more than 500°C is defined as a resid boiling range fraction.

[0027] In this discussion, the content of n-paraffins and/or isoparaffins in a fraction, product, or other composition can be determined according to UOP 990. Isoparaffins refer to any non-cyclic alkane that has at least one branch. The content of naphthenes in a composition, or the combined content of naphthenes plus aromatics in a composition, can be determined according to UOP 990. The content of total aromatics in a fraction or one-ring aromatics in a fraction can be determined according to ASTM D8368. A one-ring aromatic is defined as a compound that includes a single aromatic ring. Based on the relatively narrow boiling range of some of the compositions described herein, one-ring aromatics in the compositions will typically have substituents corresponding to carbon chains and/or non-aromatic rings.

[0028] Unless otherwise specified, the “Liquid Hourly Space Velocity (LHSV)” for a feed or portion of a feed to a reactor is defined as the volume of feed per hour relative to the volume of catalyst in the reactor. In some specific instances, a liquid hourly space velocity may be specified relative to a specific catalyst within a reactor that contains multiple catalyst beds.

[0029] As used herein, the term “renewable diesel” refers to a hydrocarbon product produced from bio-derived feedstocks. Similarly, “renewable jet” refers to a hydrocarbon product produced from bio-derived feedstocks. Examples of typical feedstocks for renewable diesel production include diglycerides, monoglycerides, triglycerides, fatty acid methyl esters (FAME), free fatty acids, and the like, which are often derived from plant oils, animal fats, or algae oils. Other examples of feedstocks can include used cooking oil and/or other waste bio-derived feedstocks. Relatedly, the term “bio-diesel” generally refers to fatty acid methyl esters or FAME.

[0030] In this discussion, a “Cx” hydrocarbon refers to a hydrocarbon compound that includes “x” number of carbons in the compound. A stream containing “Cx-Cy” hydrocarbons refers to a stream composed of one or more hydrocarbon compounds that includes at least “x” carbons and no more than “y” carbons in the compound. It is noted that a stream containing “Cx-Cy” hydrocarbons may also include other types of hydrocarbons, unless otherwise specified.

[0031] In this discussion, reference may be made to gas or vapor portions of an effluent or product versus liquid portions of an effluent or product. In this discussion, a gas product portion or gas effluent portion refers to an effluent portion or product portion that would be in the gas phase at 20°C and 100 kPa-a. Similarly, a liquid product portion or liquid effluent portion refers to an effluent portion or product portion that would be in the liquid phase at 20°C and 100 kPa-a. In this discussion, when describing the current state of an effluent portion or product portion (such as the state of a portion or fraction under the conditions present at the exit from a reaction stage), the effluent portion or product portion is described as being in the gas phase or as being in the liquid phase. For example, due to the elevated temperature and pressure in a hydroprocessing stage (such as a hydrotreating stage or a dewaxing stage), the liquid effluent portion of the hydroprocessing effluent may be present partially or entirely in the gas phase.

[0032] Certain aspects and features are described herein using a set of numerical upper limits and a set of numerical lower limits. It should be appreciated that ranges from any lower limit to any upper limit are contemplated unless otherwise indicated. All numerical values are “about” or “approximately” the indicated value, and account for experimental errors and variations that would be expected by a person having ordinary skill in the art.

Feedstock

[0033] In various aspects, jet boiling range fractions can be formed from any convenient type of bio-derived feedstock, where the term “bio-derived feedstock” refers to a hydrocarbon

feedstock derived from a biological raw material source, such as vegetable, animal, fish, and/or algae. For example, suitable feedstocks include diglycerides, monoglycerides, triglycerides, fatty acid methyl esters (FAME), free fatty acids, and the like, derived from plant oils, animal fats, or algae oils. Other examples of feedstocks can include used cooking oil and/or other waste bio-derived feedstocks. In some aspects, a feedstock can be pretreated to remove metals, gums, and other contaminants (such as refined, bleached, and deodorized (RBD) grade vegetable oil).

[0034] As used herein, the term “vegetable oil” (or “vegetable fat”) refers generally to any plant-based material and can include fats/oils derived from plant sources, such as plants of the genus *Jatropha*. Generally, the biological sources used for the bio-derived feedstock can include vegetable oils/fats, animal oils/fats, fish oils, pyrolysis oils, and/or algae lipids/oils, as well as any components of such biological sources. In some embodiments, the biological sources specifically include one or more types of lipid compounds, where the term “lipid compound” generally refers to a biological compound that is insoluble in water, but soluble in nonpolar (or fat) solvents. Non-limiting examples of such solvents include alcohols, ethers, chloroform, alkyl acetates, benzene, and combinations thereof.

[0035] Major classes of lipids include, but are not necessarily limited to, fatty acids, glycerol-derived lipids (including fats, oils, and phospholipids), sphingosine-derived lipids (including ceramides, cerebroside, gangliosides, and sphingomyelins), steroids and their derivatives, terpenes and their derivatives, fat-soluble vitamins, certain aromatic compounds, and long-chain alcohols and waxes. In living organisms, lipids generally serve as the basis for cell membranes and as a form of fuel storage. Lipids can also be found conjugated with proteins or carbohydrates, such as in the form of lipoproteins and lipopolysaccharides.

[0036] Examples of vegetable oils that can be used according to embodiments described herein include, but are not limited to, rapeseed (canola) oil, soybean oil, coconut oil, sunflower oil, palm oil, palm kernel oil, peanut oil, linseed oil, tall oil, com oil, castor oil, jatropha oil, jojoba oil, olive oil, flaxseed oil, camelina oil, safflower oil, babassu oil, tallow oil, and rice bran oil. According to embodiments described herein, vegetable oils can also include processed vegetable oil material. Non-limiting examples of processed vegetable oil material include fatty acids and fatty acid alkyl esters. Alkyl esters typically include C₁-C₅ alkyl esters. One or more of methyl, ethyl, and propyl esters are preferred.

[0037] Examples of animal fats that can be used according to embodiments described herein include, but are not limited to, beef fat (tallow), hog fat (lard), turkey fat, fish fat/oil,

and chicken fat. The animal fats can be obtained from any suitable source, including restaurants and meat production facilities. According to embodiments described herein, animal fats can also include processed animal fat material. Non-limiting examples of processed animal fat material include fatty acids and fatty acid alkyl esters. Alkyl esters typically include C₁-C₅ alkyl esters. One or more of methyl, ethyl, and propyl esters are preferred.

[0038] Algae oils or lipids are typically contained in algae in the form of membrane components, storage products, and metabolites. Certain algal strains, particularly microalgae such as diatoms and cyanobacteria, contain proportionally high levels of lipids. Algal sources for the algae oils can contain varying amounts, e.g., from 2 wt% to 40 wt% of lipids, based on the total weight of the biomass itself. Algal sources for algae oils include, but are not limited to, unicellular and multicellular algae. Examples of such algae include rhodophyte, chlorophyte, heterokontophyte, tribophyte, glaucophyte, chlorarachniophyte, euglenoid, haptophyte, cryptomonad, dinoflagellum, phytoplankton, and the like, and combinations thereof. In one embodiment, algae can be of the classes Chlorophyceae and/or Haptophyta. Specific species can include, but are not limited to, *Neochloris oleoabundans*, *Scenedesmus dimorphus*, *Euglena gracilis*, *Phaeodactylum tricornutum*, *Pleurochrysis carterae*, *Prymnesium parvum*, *Tetraselmis chui*, and *Chlamydomonas reinhardtii*.

[0039] Moreover, according to embodiments described herein, the bio-derived feedstock can include any feedstock that consists primarily of triglycerides and free fatty acids (FFAs). The triglycerides and FFAs typically contain aliphatic hydrocarbon chains in their structure having from 8 to 36 carbons, or preferably from 10 to 26 carbons, or most preferably from 14 to 22 carbons. Types of triglycerides can be determined according to their fatty acid constituents. The fatty acid constituents can be determined according to AOCS Ce 1j-07. This analysis involves extracting the fat or oil, saponifying (hydrolyzing) the fat or oil, preparing an alkyl (e.g., methyl) ester of the saponified fat or oil, and determining the type of (methyl) ester using GC analysis. In one embodiment, a majority (i.e., greater than 50%) of the triglyceride present in the lipid material can consist of C₁₀ to C₂₆ fatty acid constituents, based on the total triglyceride present in the lipid material.

[0040] Furthermore, a triglyceride is a molecule having a structure substantially identical to the reaction product of glycerol and three fatty acids. Thus, although a triglyceride is described herein as consisting of fatty acids, it should be understood that the fatty acid component does not necessarily contain a carboxylic acid hydrogen. In one embodiment, a majority of triglycerides present in the biocomponent feed can preferably consist of C₁₂ to C₁₈

fatty acid constituents, based on the total triglyceride content. Other types of feeds that are derived from biological raw material components can include fatty acid esters, such as fatty acid alkyl esters (e.g., FAME and/or FAEE).

- [0041] In general, most types of glyceride-based feedstocks correspond to feedstocks containing C₁₈ to C₂₂ carbon chains. This is due to the types of carbon chains found in common vegetable oils and animal fats. Depending on the source, some C₁₆- and/or C₂₄₊ carbon chains can also be present. In some aspects, 80 wt% or more of a feedstock used for forming a distillate composition can correspond to C₁₆ to C₂₂ carbon chains, or 90 wt% or more. In some aspects, 80 wt% or more of a feedstock used for forming a distillate composition can correspond to C₁₈ to C₂₂ carbon chains, or 90 wt% or more.

Hydrotreatment for Hydrodeoxygenation

- [0042] In various aspects, the bio-derived feedstock can be exposed to hydrotreatment conditions for deoxygenation of the feedstock. The hydrotreatment can be performed in any convenient type of hydrotreatment reactor, such as fixed bed or trickle-bed reactor.
- [0043] A hydrotreatment catalyst can contain at least one of Group VIB and/or Group VIII metals, optionally on a support such as alumina or silica. Examples include, but are not limited to, NiMo, CoMo, and NiW supported catalysts. In some embodiments, NiMo and Mo on alumina are preferred catalysts.

- [0044] Effective hydrotreatment conditions can be selected according to the details of each specific implementation. In a preferred embodiment, the hydrotreatment conditions include a total pressure of 200 psig to 2000 psig (~1.4 MPa-g to 14 MPa-g), a weighted average bed temperature (WABT) of 260 °C (i.e., 500 °F) to 400 °C (i.e., 752 °F), a hydrogen-rich treat gas rate of 200 standard cubic feet of gas per barrel of feedstock (scf/bbl) to 10,000 scf/bbl (~ 34 Nm³/m³ to 1700 Nm³/m³), and a liquid hourly space velocity (LHSV) of about 0.1 hr⁻¹ to about 10.0 hr⁻¹. In some aspects, the oxygen content of the resulting hydrotreated feedstock is less than about 0.4 wt% or less than about 0.1 wt% such as down to having substantially no oxygen content (less than 1.0 wppm). Without being bound by any particular theory, it is believed that residual oxygenates in the hydrotreated feedstock convert to H₂O and CO during the deep dewaxing process, thus inhibiting the isomerization activity of the isomerization/dewaxing catalyst.

- [0045] Optionally, a hydrotreatment reactor can be used that operates at a relatively low total pressure values, such as total pressures of about 200 psig (1.4 MPa-g) to about 800 psig (5.5 MPa-g). For example, the pressure in a stage in the hydrotreatment reactor can be at least

about 200 psig (1.4 MPa), or at least about 300 psig (2.1 MPa), or at least about 400 psig (2.8 MPa), or at least about 450 psig (3.1 MPa). The pressure in a stage in the hydrotreatment reactor can be about 800 psig (5.5 MPa) or less, or about 700 psig (4.8 MPa) or less, or about 600 psig (4.1 MPa) or less.

- 5 [0046] In some embodiments, the sulfur and nitrogen contents of the feedstock may be advantageously reduced during the hydrotreatment process. For example, in some embodiments, the hydrotreatment process reduces the sulfur content of the feedstock to a suitable level, such as, for example, less than about 100 weight parts per million (wppm), less than about 50 wppm, less than about 30 wppm, less than about 25 wppm, less than about 20
10 wppm, less than about 15 wppm, or less than about 10 wppm, such as down to 0.1 wppm or possibly still lower. With regard to nitrogen, in some embodiments, the hydrotreatment process reduces the nitrogen content of the feedstock to a suitable level, such as, for example, about 30 wppm or less, about 25 wppm or less, about 20 wppm or less, about 15 wppm or less, about 10 wppm or less, about 5 wppm or less, or about 3 wppm or less, such as down to 0.1 wppm or
15 possibly still lower.

- [0047] In various embodiments, the hydrotreatment process is also used to deoxygenate the feedstock. Deoxygenating the feedstock may help to avoid problems with catalyst poisoning or deactivation due to the creation of water (H₂O) or carbon oxides (e.g., CO and CO₂) during catalytic dewaxing. Accordingly, the hydrotreatment process can be used to
20 remove, for example, at least 90%, at least 95%, at least 98%, at least 99%, at least 99.5%, at least 99.9%, or completely (measurably) all of the oxygen present in the deoxygenated feedstock. Alternatively, the oxygenate level of the feedstock can be reduced to, for example, 0.1 wt% or less, 0.05 wt % or less, 0.03 wt % or less, 0.02 wt% or less, 0.01 wt% or less, 0.005 wt% or less, 0.003 wt% or less, 0.002 wt% or less, or 0.001 wt% (10 wppm)
25 or less, such as down to having substantially no oxygen content remaining in the deoxygenated feedstock (less than 1.0 wppm).

- [0048] In aspects where the feedstock for hydrotreatment includes a sufficiently high content of components having a C₁₇₊ carbon chain, the resulting deoxygenated effluent can have a correspondingly high content of C₁₇₊ n-paraffins. In such aspects, the liquid portion
30 of the deoxygenated effluent can contain 50 wt% or more of C₁₇₊ n-paraffins, or 60 wt% or more, or 70 wt% or more, or 80 wt% or more, such as up to 95 wt% or possibly still higher.

Separation Between Hydrotreatment and Catalytic Dewaxing

[0049] In various aspects, a separation stage can be used to separate out impurities from the hydrotreated feedstock prior to passing the hydrotreated feedstock to the isomerization/dewaxing reactor. In particular, the separation process minimizes the amount of H₂O and CO that is slipped into the isomerization/dewaxing reactor by separating the gas and liquid phases within the hydrotreated feedstock. While an interstage stripper is preferred for this purpose, any suitable separation device can be used, such as, for example, any suitable type of separator or fractionator that is configured to separate gas-phase products from liquid-phase products.

[0050] In some aspects, the gas phase exiting the separation device can be recycled and combined with the hydrogen-rich treat gas that is fed into the hydrotreatment reactor. In addition, in various aspects, a portion of the liquid phase exiting the separation stage can be recycled back into the hydrotreatment reactor to provide improved heat release control for the hydrotreatment reactor.

Catalytic Dewaxing

[0051] In various aspects, at least a portion of the deoxygenated effluent is then exposed to catalyst that dewaxes substantially based on isomerization. Dewaxing catalysts based on the zeolite ZSM-48 are examples of such catalysts. ZSM-48 is a 10-member ring, one-dimensional zeolite of the MRE framework type. ZSM-48 based catalysts have a high selectivity for isomerization of paraffinic feeds relative to cracking. Thus, in some aspects, a ZSM-48 based catalyst can provide substantially complete isomerization of a paraffinic feed (such as a deoxygenated bio-derived feed) while reducing or minimizing cracking of the paraffinic carbon chains. In other aspects, other types of dewaxing catalysts based on 10-member ring, one-dimensional zeotypes may also be used, such as dewaxing catalysts based on the zeolite frameworks corresponding to ZSM-23, EU-2, EU-11, and/or ZBM-30. In some aspects, the catalyst can consist essentially of ZSM-48, any optional binder, and a hydrogenation metal, so that less than 1.0 wt% or less of the catalyst (relative to the weight of the catalyst) corresponds to a zeolite structure different from an MRE framework structure, or less than 0.1 wt%, such as down to having substantially no zeolite content different from an MRE framework structure (0.01 wt% or less). In some aspects, the ZSM-48 in the catalyst can have a silica to alumina ratio of 90 : 1 or less, or 75 : 1 or less, such as down to 60 : 1 or possibly still lower.

[0052] Optionally but preferably, the dewaxing catalyst can include a binder, such as alumina, titania, silica, silica-alumina, zirconia, or a combination thereof, for example alumina and/or titania or silica and/or zirconia and/or titania. The relative amount of a zeolite

framework structure (such as a MRE zeotype framework) and binder can be any convenient amount. In some aspects where a binder is present, the catalyst can include 1.0 wt% to 85 wt% of a binder and/or can include 15 wt% to 99 wt% of a zeotype framework structure.

[0053] In addition to zeotype framework and optional binder, the dewaxing catalyst can also include at least one metal hydrogenation component selected from Pd, Pt, or a combination thereof. When a metal hydrogenation component is present, the dewaxing catalyst can include 0.1 wt% to 10 wt% of the Pt, Pd, or combination thereof, or 0.1 wt% to 5.0 wt%, or 0.5 wt% to 10 wt%, or 0.5 wt% to 5.0 wt%, or 1.0 wt% to 10 wt%, or 1.0 wt% to 5.0 wt%.

[0054] The isomerization/dewaxing reactor may include any suitable type of reactor arranged in any suitable configuration. For example, in some embodiments, the isomerization/dewaxing reactor is a fixed-bed adiabatic reactor or a trickle-bed reactor that is loaded with a ZSM-48-based isomerization/dewaxing catalyst.

[0055] The deoxygenated feedstock (or at least a portion thereof, such as the liquid product portion) is exposed to the isomerization/dewaxing catalyst under effective isomerization/dewaxing conditions. The effective conditions are selected to provide sufficient severity so that substantially complete dewaxing occurs for the n-paraffins in the deoxygenated effluent while still reducing or minimizing cracking. In various aspects, the isomerization / dewaxing conditions include a total pressure of 200 psig (1.4 MPa-g) to 2000 psig (14 MPa-g), a WABT of 300°C to 350°C, a treat gas rate of 200 scf/bbl to 10,000 scf/bbl (~34 Nm³/m³ to 1700 Nm³/m³), and an LHSV of 1.0 hr⁻¹ to about 8.0 hr⁻¹ (relative to a volume of the dewaxing catalyst).

[0056] In various aspects, after hydrotreating and catalytic dewaxing, the oxygen content of the liquid dewaxing effluent can be less than 10 wppm, or less than 2.0 wppm, such as down to having substantially no oxygen content (1.0 wppm or less).

25 Properties of Hydroprocessed Product and Distillate Boiling Range Product

[0057] After dewaxing, the resulting dewaxed effluent can have a variety of properties. Prior to separation, the liquid portion of the dewaxed effluent roughly corresponds to a combination of a jet boiling range fraction and additional higher boiling components that correspond to a distillate boiling range composition after the jet boiling range fraction is separated from the dewaxing effluent. Optionally, some naphtha boiling range components may also be present. In some aspects, the liquid portion of the dewaxed effluent (i.e., the portion that is a liquid at 20°C and 100 kPa-a) can have a T10 distillation point of 205°C or higher, or 220°C or higher. Additionally or alternately the liquid portion of the dewaxed effluent can have

a T90 distillation point of 310°C or less, or 300°C or less, or 290°C or less. It is noted that the T90 distillation point is always equal to or greater than the temperature of the T10 distillation point, so the T10 distillation point acts as a lower bound on the T90 distillation point, while the T90 distillation point acts as an upper bound on the T10 distillation point.

5 [0058] It is noted that due to the deep dewaxing, the liquid portion of the dewaxed effluent can have a relatively high content of isoparaffins and/or relatively low content of n-paraffins in the composition. In various aspects, 80 wt% or more of the dewaxed effluent can correspond to paraffins (n-paraffins plus isoparaffins), or 85 wt% or more, or 90 wt% or more, such as up to substantially all of the hydrocarbons in the composition corresponding to paraffins. In some
10 aspects, the liquid portion of the dewaxed effluent can include 15 wt% or less of n-paraffins, or 10 wt% or less, or 5.0 wt% or less, such as down to substantially no n-paraffins (1.0 wt% or less). Additionally or alternately, the liquid portion of the dewaxed effluent can include 80 wt% or more of isoparaffins, or 85 wt% or more, or 90 wt% or more, such as up to 99 wt% or possibly still higher.

15 [0059] In various aspects, the liquid portion of the dewaxed effluent can have one or more of the following properties. The liquid portion of the dewaxed effluent can have a density at 15°C of 765 kg/m³ or more, or 765 kg/m³ or more, or 770 kg/m³ or more, such as up to 790 kg/m³ or possibly still higher. The liquid portion of the dewaxed effluent can have a freeze point of -20°C or less, or -30°C or less, such as down to -80°C or possibly still lower. The
20 liquid portion of the dewaxed effluent can have a cloud point of -20°C or less, or -30°C or less, or -30°C or less, such as down to -60°C or possibly still lower. The liquid portion of the dewaxed effluent can have a cold filter plugging point of -20°C or less, or -30°C or less, or -40°C or less, such as down to -70°C or possibly still lower. The liquid portion of the dewaxed effluent can have a kinematic viscosity at 40°C of 2.0 cSt to 4.1 cSt, or 2.0 cSt to 3.8 cSt, or
25 2.5 cSt to 4.1 cSt, or 2.5 cSt to 3.8 cSt.

[0060] In some aspects, the liquid portion of the dewaxed effluent can have a sulfur content of 100 wppm or less (determined according to (ASTM D5343), or 50 wppm or less, or 15 wppm or less, such as down to 0.1 wppm or possibly still lower. It is noted that due to the bio-derived nature of the liquid portion of the dewaxed effluent, the sulfur content can be relatively
30 low, such as being substantially free of sulfur. Similarly, due to the hydrodeoxygenation and dewaxing steps, the oxygen content of the liquid portion of the dewaxed effluent can be relatively low, such as substantially free of oxygen. Thus, in some aspects, the oxygen content of the liquid portion of the dewaxed effluent can be 100 wppm or less, or 10 wppm or less, or

5.0 wppm or less, or 1.0 wppm or less, such as down to having substantially no oxygen content (0.1 wppm or less). The oxygen content can be determined according to ASTM E385.

Properties of Distillate Boiling Range Product

[0061] After dewaxing, the resulting dewaxed effluent can be separated to form at least a product including a jet boiling range fraction and a distillate boiling range composition. Any convenient type of separation(s) can be used to form the distillate boiling range composition and the jet boiling range fraction. In various aspects, the distillate boiling range composition (formed after one or more separations) can have a T10 distillation point of 290°C or higher, or 295°C or higher, in combination with a T90 distillation point of 320°C or less, or 315°C or less, or 310°C or less, or 305°C or less, or 300°C or less. It is noted that the T90 distillation point is always equal to or greater than the temperature of the T10 distillation point, so the T10 distillation point acts as a lower bound on the T90 distillation point, while the T90 distillation point acts as an upper bound on the T10 distillation point. Additionally or alternately, the distillate boiling range composition can have a difference between the T10 distillation point and the T90 distillation point of 25°C or less, or 20°C or less, or 10°C or less, such as down to 2.5°C or possibly still lower. To illustrate such a difference, consider a hypothetical distillate boiling range fraction with a T10 distillation point of 291°C and a T90 distillation point of 310°C. Such a fraction would have a difference between the T10 distillation point and the T90 distillation point of 19°C. In some aspects, the distillate boiling range composition can have a final boiling point of 310°C to 340°C, or 310°C to 330°C.

[0062] The narrow boiling range is due in part to a relatively narrow distribution of carbon chain lengths within the distillate boiling range composition. Because a jet boiling range composition is formed at the same time, the resulting distillate boiling range composition has a reduced or minimized content of C₁₆₋ carbon chains. Due to the feedstock being a glyceride-based feed, the resulting distillate boiling range composition also has a reduced or minimized content of C₂₁₊ carbon chains. In some aspects, 90 wt% or more of the distillate boiling range composition corresponds to compounds having C₁₇₊ carbon chains, or 95 wt% or more, such as up to substantially all of the composition. In some aspects, 60 wt% or more of the distillate boiling range composition corresponds to compounds having C₁₈₊ carbon chains, or 65 wt% or more, or 70 wt% or more, such as up to substantially all of the composition. In some aspects, 90 wt% or more of the distillate boiling range composition can correspond to compounds having C₁₇ – C₂₀ carbon chains, or 95 wt% or more, such as up to substantially all of the composition. In some aspects, 60 wt% or more of the distillate boiling range composition

corresponds to compounds having C₁₈ – C₂₀ carbon chains, or 65 wt% or more, or 70 wt% or more, such as up to substantially all of the composition.

[0063] In addition to having a relatively narrow boiling range, the distillate boiling range composition can also have beneficial cold flow properties. This is due in part to the relatively high content of isoparaffins and/or relatively low content of n-paraffins in the composition. In various aspects, 80 wt% or more of the distillate boiling range composition can correspond to paraffins (n-paraffins plus isoparaffins), or 85 wt% or more, or 90 wt% or more, such as up to substantially all of the hydrocarbons in the composition corresponding to paraffins. In some aspects, the distillate boiling range composition can include 15 wt% or less of n-paraffins, or 10 wt% or less, or 5.0 wt% or less, such as down to substantially no n-paraffins (1.0 wt% or less). Additionally or alternately, the distillate boiling range composition can include 80 wt% or more of isoparaffins, or 85 wt% or more, or 90 wt% or more, such as up to 99 wt% or possibly still higher.

[0064] In some aspects, the distillate boiling range composition can include 0.5 wt% to 4.0 wt% of naphthenes, aromatics, or a combination thereof, or 1.0 wt% to 4.0 wt%, or 0.5 wt% to 2.5 wt%, or 1.0 wt% to 2.5 wt%, or 0.5 wt% to 1.5 wt%. In some aspects, the distillate boiling range composition can include 0.1 wt% to 4.0 wt% of total aromatics, or 0.1 wt% to 2.5 wt%, or 0.2 wt% to 4.0 wt%, or 0.2 wt% to 2.5 wt%, or 0.5 wt% to 4.0 wt%, or 0.5 wt% to 2.5 wt%. In some aspects, the distillate boiling range composition can include 0.07 wt% to 4.0 wt% of one-ring aromatics, or 0.07 wt% to 2.5 wt%, or 0.1 wt% to 4.0 wt%, or 0.1 wt% to 2.5 wt%, or 0.2 wt% to 4.0 wt%, or 0.2 wt% to 2.5 wt%.

[0065] In various aspects, the distillate boiling range composition can have one or more of the following properties. The distillate boiling range composition can have a density at 15°C of 765 kg/m³ or more, or 765 kg/m³ or more, or 768 kg/m³ or more, or 770 kg/m³ or more, such as up to 800 kg/m³ or possibly still higher. The distillate boiling range composition can have a freeze point of -10°C or less, or -20°C or less, such as down to -50°C or possibly still lower. The distillate boiling range composition can have a cloud point of -10°C or less, or -20°C or less, or -30°C or less, such as down to -50°C or possibly still lower. The distillate boiling range composition can have a cold filter plugging point of -15°C or less, or -20°C or less, or -25°C or less, such as down to -50°C or possibly still lower. The distillate boiling range composition can have a kinematic viscosity at 40°C of 2.5 cSt to 4.5 cSt, or 2.5 cSt to 4.1 cSt, or 3.0 cSt to 4.5 cSt, or 3.0 cSt to 4.1 cSt. In some aspects, the distillate boiling range composition can have a total acidity (determined according to ASTM D664) of 0.05 mg KOH/g or less.

[0066] Due in part to the highly paraffinic nature of the distillate boiling range composition, and the relatively narrow boiling range, the diesel combustion properties of the composition can be favorable. In some aspects, the distillate boiling range composition can have a derived cetane number (according to ASTM D7688) of 70 or more, or 80 or more, or 5 90 or more, such as up to 110 or possibly still higher. Additionally or alternately, the distillate boiling range composition can have a cetane number (ASTM D613) of 70 or more, or 80 or more, or 90 or more, such as up to 110 or possibly still higher.

[0067] In some aspects, the distillate boiling range composition can have a sulfur content of 100 wppm or less (determined according to (ASTM D5453), or 50 wppm or less, or 15 10 wppm or less, such as down to 0.1 wppm or possibly still lower. It is noted that due to the bio-derived nature of the distillate boiling range composition, the sulfur content can be relatively low, such as being substantially free of sulfur. Similarly, due to the hydrodeoxygenation and dewaxing steps, the oxygen content of the distillate boiling range composition can be relatively low, such as substantially free of oxygen. Thus, in some aspects, the oxygen content of the 15 distillate boiling range composition can be 100 wppm or less, or 10 wppm or less, or 5.0 wppm or less, or 1.0 wppm or less, such as down to having substantially no oxygen content (0.1 wppm or less).

[0068] The distillate boiling range composition can be used in a variety of applications. For example, the distillate boiling range composition can be used as-is (i.e. as a neat product) 20 as a coolant and/or heat transfer fluid or in a coolant and/or heat transfer formulation. Such coolant and/or heat transfer fluids include, among others, battery coolants, coolants for data storage, process coolant fluids, heat transfer fluids, and electric vehicle fluids such as coolant or heat transfer fluid for batteries, motors and/or electrical components. Optionally, the distillate boiling range composition can be used in combination with ingredients typically used 25 in coolants and heat transfer fluids. In such applications, the distillate boiling range composition can provide a combination of favorable cold flow properties, a relatively high flash point, and relatively low aromatics content.

[0069] As another example, the distillate boiling range composition can be used in acrylic and silicone mastics and sealants, for instance as silicone oil extender. Acrylic and silicone 30 mastics and sealants are used as elastic jointing material to exclude dust, dirt and moisture, to contain liquid and gases, to insulate and fill space, and to reduce noise and vibration. In some aspects, the distillate boiling range composition can be used in acrylic and silicone mastics and sealants, paints, coatings, and adhesives. This is due in part to the distillate boiling range

composition having good cold flow properties (such as low pour point) which is needed for outdoor applications in cold weather; low aromatics which results in an improved odor and improved safety but also ensures good color stability (no yellowing with UV exposure); increased compatibility and solvency which enables the use of a higher percentage of the distillate boiling range composition as extender oil in the acrylic and silicone mastics and sealants; and decreased shrinkage due in part to a relatively high flash point. Additionally or alternately, the distillate boiling range composition can also be used in reprographic applications, such as printing ink distillates for off-set printing, piezo ink jet technology, cold-set printing, and heat-set printing.

10 [0070] The distillate boiling range composition can also be used as drilling fluid or as base oil for the formulation of drilling muds. This is due in part to the distillate boiling range composition having good cold flow properties (such as low pour point), high compatibility or solvency, and low aromatics content.

15 [0071] Still other examples of applications for the distillate boiling range composition can include, but are not limited to, use as a process oil; use in consumer products (e.g., cosmetics); use in agricultural chemicals (such as formulation in pesticides and/or spray oils); use in water treatment; use as a dielectric fluid, such as a transformer oil; use in construction projects; and use as a lubricant, such as for demolding. Generally, the favorable cold flow properties, high compatibility or solvency, and low aromatics content can be beneficial for various types of applications.

20 Configuration Example

[0072] The Figure shows an example of a reaction system 100 for producing a dewaxed effluent that includes a jet boiling range product and a distillate boiling range composition. As shown in the Figure, a bio-derived feedstock 102 is introduced into a hydrotreatment reactor 104. A first portion 106 of a hydrogen-rich treat gas stream 108 is also introduced into the hydrotreatment reactor 104. It will be appreciated by one of skill in the art that, while the hydrogen-rich treat gas stream 108 is depicted in the Figure as entering the top of the hydrotreatment reactor 104, this is for the sake of simplicity only. In operation, the hydrogen-rich treat gas stream 108 may be introduced into the hydrotreatment reactor 104 at various locations, such as at quench locations corresponding to each reactor bed.

30 [0073] The bio-derived feedstock 102 is then exposed to effective hydrotreatment conditions in the hydrotreatment reactor 104 in the presence of one or more catalyst beds that contain a suitable hydrotreating catalyst, resulting in the generation of a hydrotreated feedstock

110. At least a portion of the hydrotreated feedstock 110 exiting the hydrotreatment reactor is then introduced into a separation device 112, such as an interstage stripper. Within the separation device 112, a gas product portion is separated from liquid product portion. The gas product portion is then output as a first overhead stream 114 that can optionally be recycled and combined with the first portion 106 of the hydrogen-rich treat gas stream 108 entering the hydrotreatment reactor 104. In addition, the liquid product portion corresponds to liquid stream 116.

[0074] As shown in the Figure, some portion of the liquid stream 116 may (optionally) be recycled back into the hydrotreatment reactor 104 to provide heat release control for the hydrotreatment reactor 104. The rest of the liquid stream 116 (or the entirety of the liquid stream 116 for embodiments that do not include liquid recycling) is then introduced into an isomerization/dewaxing reactor 118. A second portion 120 of the hydrogen-rich treat gas stream 108 is also introduced into the isomerization/dewaxing reactor 118. It will be appreciated by one of skill in the art that, while the hydrogen-rich treat gas stream 108 is depicted in the Figure as entering the top of the isomerization/dewaxing reactor 118, this is for the sake of simplicity only. In operation, the hydrogen-rich treat gas stream 108 may be introduced into the isomerization/dewaxing reactor 118 at various locations, such as at the quench locations corresponding to each reactor bed.

[0075] Within the isomerization/dewaxing reactor 118, the liquid stream 116 is exposed to suitable catalytic isomerization/dewaxing conditions in the presence of one or more catalyst beds that contain an isomerization/dewaxing catalyst, resulting in the generation of an isomerized product stream 122. Finally, the isomerized product stream 122 exiting the isomerization/dewaxing reactor 118 is flowed through one or more separation stages 124. Within the separation stage(s) 124, the isomerized product stream 122 is separated into a lower boiling fraction 126, a jet boiling range product 130, and a distillate boiling range composition 140. Optionally, a portion 144 of the distillate boiling range composition 140 can be recycled for use as part of the input flow to hydrotreatment reactor 104 and/or as part of the input flow for isomerization / dewaxing reactor 118.

[0076] In some aspects, it is noted that multiple distillate boiling range products could be formed. For example, a light distillate boiling range product and a heavy distillate boiling range product can be formed. More generally, any convenient number of jet boiling range and/or distillate boiling range compositions can be formed from the liquid portion of the dewaxed effluent.

[0077] The schematic views of the reaction systems in the figures are not intended to indicate that the reaction systems are required to include all of the components shown in the figures, or that the reaction systems are limited to only the components shown in the figures. Rather, any number of components may be omitted from the reaction systems, or added to the reaction systems, depending on the details of the specific implementation. For example, in some embodiments, the separation device 112 in the Figure is omitted from the reaction system 100, and the hydrotreated feedstock is passed directly from the hydrotreatment reactor 104 to the isomerization/dewaxing reactor 118. Moreover, in some embodiments, multiple hydrotreatment reactors and/or multiple isomerization/dewaxing reactors are included within a reaction system. As still another example, while the reaction system 100 in FIG. 1 is depicted as including separate hydrotreatment and isomerization/dewaxing reactors 104 and 118, respectively, one of skill in the art will appreciate that the hydrotreatment and isomerization/dewaxing stages can alternatively be combined into a single reactor without changing the overall technical effect of the reaction system 100.

15 **EXAMPLES**

Example 1

[0078] A pilot scale reaction system having a configuration similar to the Figure was used to form a distillate boiling range composition. The dewaxing stage included a Pt/ZSM-48 bound catalyst having 0.6 wt% Pt relative to the weight of the catalyst. The ZSM-48 had a silica to alumina ratio of roughly 70 : 1. The input feed to the pilot scale reaction system corresponded to a soybean oil feed, so that the feed substantially contained molecules containing C₁₈₊ carbon chains.

[0079] Table 1 shows results from characterization of the distillate boiling range composition (Sample 1) that was formed after separation of the lower boiling portions of the liquid fraction. For comparison, Table 1 also shows parts of the specifications found in ASTM D975 and EN 15940, as well as characterization of a representative commercial No. 2 diesel sample. It is noted that the paraffin contents shown in Table 1 that were measured according to UOP 990 correspond to combined n-paraffins and isoparaffins in the sample.

Table 1 – Properties of Distillate Boiling Range Composition

Method	Description	Unit	ASTM D975 Specification (2-D S15)	EN 15940 Specification (Class A)	Sample 1	No. 2 Diesel
D4052	Density, 15 °C	g/mL	-	Min 0.7650 Max 0.8000	0.7896	0.8610
D445	Viscosity @ 40 °C	cSt	Min 1.9 Max 4.1	Min 2.000 Max 4.500	4.059	3.1
D664	Acid Number	mg KOH/g	-	-	<0.05	-
D1159	Bromine Number	Value	-	-	<1	-
D86	Initial Boiling Point	°C	-	Report	258.8	177.5
D86	T10	°C	-	-	293.1	218.7
D86	T50	°C	-	-	294.8	269.1
D86	T90	°C	Min 282 Max 338	-	303.7	330.3
D86	% (V/V) Recovered at 250 °C	% (V/V)	-	Max <65	0	-
D86	% (V/V) Recovered at 350 °C	% (V/V)	-	Min 85	100	-
D86	95% (V/V) Recovered at	°C	-	Max 360.0	326.4	347.1
D86	Final boiling point	°C	-	-	327.2	355.8
EN 12916	Aromatics (1- Ring)	Mass%	-	-	0.2	28.3
EN 12916	Aromatics (2- Ring)	Mass%	-	-	0.0	2.4
EN 12916	Aromatics (3- Ring)	Mass%	-	-	0.0	0.2
EN 12916	Aromatics (Total)	Mass%	-	Max 1.1	0.2	30.9
D5773	Cloud Point	°C	Report	Report	-25	-21
D6371	Cold Filter Plugging Point	°C	-	Max Grade F -20	-27	-26
D5972	Freezing Point	°C	-	-	-22.1	-
D7668	Derived Cetane Number	Value	-	-	91.6	43.0
D613	Cetane Number	Value	Min 40	Min 70	-	40.1
UOP 990	Paraffins (n- plus iso-) C9 to C14	wt.%	-	-	0.0	9.88
UOP 990	Paraffins (n- plus iso-) C15 to C16	wt.%	-	-	1.46	2.17
UOP 990	Paraffins (n- plus iso-) C17 and higher	wt.%	-	-	97.07	10.92

UOP 990	Paraffins (n- plus iso-) C18 and higher	wt. %	-	-	66.12	8.63
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[0080] As shown in Table 1, the distillate boiling range composition met all typical constraining specification properties for both D975 and EN 15940 related to density, viscosity, distillation, aromatics, and cetane. Even though the distillate boiling range composition was a heavy renewable distillate fuel with ~97 wt% of the product with a carbon number at C₁₇ and higher and ~66 wt% at C₁₈ and higher, it still had acceptable cold flow qualities. It had a cloud point of -25°C, -27°C cold filter plugging point and freeze point of -22.1°C.

[0081] The roughly 97 wt% content of C₁₇₊ components in the distillate boiling range composition is in contrast to the typical distribution of carbon chain lengths in a conventional diesel fuel. A representative conventional diesel fuel was analyzed using UOP 990. In the conventional diesel fuel, only 11 wt% of the fuel corresponded to paraffins (n-paraffins plus isoparaffins) with carbon chain lengths of C₁₇ or more. More generally, less than 35 wt% of the conventional diesel corresponded to C₁₇₊ compounds.

Example 2

[0082] In another processing run, the reaction system was used to process a similar feed to form a dewaxed effluent. The liquid portion of the dewaxed effluent roughly corresponds to a combination of a jet boiling range fraction and a distillate boiling range fraction similar to the distillate boiling range fraction shown in Table 1. Optionally, some naphtha boiling range components can also be present. The properties of the liquid portion of the dewaxed effluent (Sample 2) are shown in Table 2.

Table 2 – Characterization of Dewaxed Effluent

Method	Description	Unit	ASTM D975 Specification (2-D S15)	EN 15940 Specification (Class A)	Sample 2
D4052	Density, 15 °C	g/mL	-	Min 0.7650 Max 0.8000	0.7799
D445	Viscosity @ 40 °C	cSt	Min 1.9 Max 4.1	Min 2.000 Max 4.500	2.876
D664	Acid Number	Value	-	-	0.05
D86	Initial Boiling Point	°C	-	Report	135.4
D86	T10	°C	-	-	246.9
D86	T50	°C	-	-	282.1

D86	T90	°C	Min 282 Max 338	-	291.8
D86	Final boiling point	°C	-	-	306.3
D5773	Cloud Point	°C	Report	Report	-37
D6371	Cold Filter Plugging Point	°C	-	Max Grade F -20	-41
D5972	Freeze Point	°C	-	-	-34
D1159	Bromine Number	Value	-	-	0
UOP 990	Paraffins (n- plus iso-) C7 to C8	wt. %	-	-	1.79
UOP 990	Paraffins (n- plus iso-) C9 to C14	wt. %	-	-	10.21
UOP 990	Paraffins (n- plus iso-) C15 to C16	wt. %	-	-	23.63
UOP 990	Paraffins (n- plus iso-) C17 and plus	wt. %	-	-	63.17
UOP 990	Paraffins (n- plus iso-) C18 and plus	wt. %	-	-	28.75

[0083] As shown in Table 2, the liquid portion of the dewaxing effluent has a broader boiling range than the distillate boiling range composition. For example, the T50 distillation point for the dewaxed effluent is 282.1°C, while the T10 distillation point for the distillate boiling range composition (Sample 1) in Table 1 is above 290°C. Additionally, the number of C₁₇₊ and/or C₁₈₊ paraffins is substantially reduced, while the amount of C₁₅ – C₁₆ paraffins is increased. There is also a modest increase in the amounts of both C₇ – C₈ paraffins and C₉ – C₁₄ paraffins.

Example 3 – Blended Products

[0084] The distillate boiling range composition corresponding to Sample 1 and the dewaxed effluent corresponding to Sample 2 were used to make blended compositions. The blends corresponded to 30 wt% of Sample 1 or Sample 2 mixed with 70 wt% of the conventional diesel shown in Table 1. Table 3 shows results from characterization of the blended products. It is noted that some of the values for the blend containing Sample 2 correspond to modeled values.

Table 3 – Characterization of Blended Products

Method	Description	Unit	ASTM D975 Specification (2-D S15)	30% Sample 1 with 70% No. 2 Diesel	30% Sample 2 with 70% No. 2 Diesel
D4052	Density, 15 °C	g/mL	-	0.8326	0.8367*

D445	Viscosity @ 40 °C	cSt	Min 1.9 Max 4.1	3.463	3.02*
D86	Initial Boiling Point	°C	-	185.7	*136
D86	T10	°C	-	235.9	*221
D86	T50	°C	-	284.2	*275
D86	T90	°C	Min 282 Max 338	320.4	*324
D86	Final boiling point	°C	-	358.9	*355
EN 12916	Aromatics (1-Ring)	Mass%	-	20.6	*20.4
EN 12916	Aromatics (2-Ring)	Mass%	-	1.8	*1.8
EN 12916	Aromatics (3-Ring)	Mass%	-	0.1	*0.1
EN 12916	Aromatics (Total)	Mass%	-	22.6	*22.3
D5773	Cloud Point	°C	Report	-25	*-32
D6371	Cold Filter Plugging Point	°C	-	-34	*-38
D7668	Derived Cetane Number	Value	-	55.21	58.6*

* Modeled Values

[0085] As shown in Table 3, blending Sample 1 or Sample 2 with a conventional diesel resulted in a blend that also had properties similar to a diesel fuel. Unexpectedly, blending 30 wt% of Sample 1 with the conventional diesel resulted in a blended product with a cloud point that was substantially the same as the cloud point of Sample 1 (-25°C), even though the cloud point of the conventional diesel was higher (-21°C).

[0086] In various aspects, the dewaxed effluent and/or a distillate boiling range composition can be blended with other fractions in any convenient amount. Such blends can include 1.0 wt% to 99 wt% of the dewaxed effluent and/or the distillate boiling range composition, or 10 wt% to 99 wt%, or 25 wt% to 99 wt%, or 1.0 wt% to 90 wt%, or 10 wt% to 90 wt%, or 25 wt% to 90 wt%. The dewaxed effluent and/or distillate boiling range composition can be blended with any convenient type of fraction. Such fractions can include mineral distillate fractions, mineral diesel fractions, mineral jet fractions, mineral resid fractions, bio-derived fractions (such as renewable diesel, renewable jet, hydrotreated vegetable oil, FAME), Fischer-Tropsch fractions, or combinations thereof. The one or more additional fractions can correspond to 1.0 wt% to 99 wt% of the blended composition, or 1.0 wt% to 90 wt%, or 1.0 wt% to 75 wt%, or 10 wt% to 99 wt%, or 10 wt% to 90 wt%, or 10 wt% to 75 wt%. It is noted that if the blended composition includes a sufficient amount of at least one resid boiling range fraction, the resulting blended composition can have a T90 distillation point of 500°C or higher. As another example, in some aspects the blended composition can

have a boiling range corresponding to a distillate fuel, such as a T10 distillation point of 170°C or more and a T90 distillation point of 370°C or less.

Additional Embodiments

5 [0087] Embodiment 1. A distillate boiling range composition, comprising 80 wt% or more of isoparaffins, 15 wt% or less of n-paraffins, a T10 distillation point of 290°C or more, a T90 distillation point of 325°C or less, and i) 0.1 wt% or more of total aromatics, ii) 0.07 wt% or more of one-ring aromatics, or iii) a combination of i) and ii).

[0088] Embodiment 2. The composition of Embodiment 1, wherein a difference between the T90 distillation point and the T10 distillation point is 20°C or less.

10 [0089] Embodiment 3. The composition of any of the above embodiments, wherein the composition has a cloud point of -20°C or less, or wherein the composition has a density of 800 kg/m³ or less, or wherein the composition has a kinematic viscosity at 40°C of 4.5 cSt or less, or a combination thereof

15 [0090] Embodiment 4. The composition of any of the above embodiments, wherein the composition comprises 85 wt% or more of isoparaffins, or wherein the composition comprises 10 wt% or less of n-paraffins, or a combination thereof.

[0091] Embodiment 5. The composition of any of the above embodiments, i) wherein the composition comprises 0.5 wt% or more of naphthenes; ii) wherein the composition comprises 1.0 wt% or more of naphthenes, aromatics, or a combination thereof; or iii) a combination of
20 i) and ii).

[0092] Embodiment 6. The composition of any of the above embodiments, wherein the composition comprises 1.0 wppm or less of oxygen, or wherein the composition comprises 10 wppm or less of sulfur, or a combination thereof.

25 [0093] Embodiment 7. The composition of any of the above embodiments, wherein the composition comprises a final boiling point of 340°C or less, or wherein the composition comprises a T90 distillation point of 310°C or less, or a combination thereof.

[0094] Embodiment 8. The composition of any of the above embodiments, wherein the composition comprises 90 wt% or more of compounds having C₁₇ – C₂₀ carbon chains.

30 [0095] Embodiment 9. A blended composition, comprising: 1.0 wt% to 99 wt% of a distillate boiling range composition according to any of Embodiments 1 – 8; and 1.0 wt% to 99 wt% of one or more distillate fractions, one or more resid fractions, or a combination thereof.

[0096] Embodiment 10. The blended composition of Embodiment 9, wherein the blended composition comprises a T10 distillation point of 170°C or more and a T90 distillation point of 370°C or less.

5 [0097] Embodiment 11. The blended composition of Embodiment 9, wherein the blended composition comprises a T90 distillation point of 500°C or more.

[0098] Embodiment 12. The blended composition of any of Embodiments 9 to 11, wherein the blended composition comprises 10 wt% to 90 wt% of the distillate boiling range composition.

10 [0099] Embodiment 13. The blended composition of any of Embodiments 9 to 12, wherein the blended composition comprises one or more distillate fractions, the blended composition comprising 25 wt% or more of the distillate boiling range composition, a cloud point of the blended composition being lower than a cloud point of the one or more distillate fractions.

[0100] Embodiment 14. The blended composition of any of Embodiments 9 to 13, wherein the one or more distillate fractions, one or more resid fractions, or a combination thereof
15 comprise at least one of a bio-derived fraction and a Fischer-Tropsch fraction.

[0101] Embodiment 15. Use of the composition of any of Embodiments 1 to 8 in a heat transfer fluid, a coolant, a process oil, an agricultural chemical, a dielectric fluid, an adhesive, a sealant, a printing ink, or a demolding oil.

20 [0102] While the present invention has been described and illustrated by reference to particular embodiments, those of ordinary skill in the art will appreciate that the invention lends itself to variations not necessarily illustrated herein. For this reason, then, reference should be made solely to the appended claims for purposes of determining the true scope of the present invention.

CLAIMS

What is claimed is:

1. A distillate boiling range composition, comprising 80 wt% or more of isoparaffins, 15 wt% or less of n-paraffins, a T10 distillation point of 290°C or more, a T90
5 distillation point of 325°C or less, and i) 0.1 wt% or more of total aromatics, ii) 0.07 wt% or more of one-ring aromatics, or iii) a combination of i) and ii).
2. The composition of claim 1, wherein a difference between the T90 distillation point and the T10 distillation point is 20°C or less.
3. The composition of any of the above claims, wherein the composition
10 has a cloud point of -20°C or less, or wherein the composition has a density of 800 kg/m³ or less, or wherein the composition has a kinematic viscosity at 40°C of 4.5 cSt or less, or a combination thereof
4. The composition of any of the above claims, wherein the composition comprises 85 wt% or more of isoparaffins, or wherein the composition comprises 10 wt% or
15 less of n-paraffins, or a combination thereof.
5. The composition of any of the above claims, i) wherein the composition comprises 0.5 wt% or more of naphthenes; ii) wherein the composition comprises 1.0 wt% or more of naphthenes, aromatics, or a combination thereof; or iii) a combination of i) and ii).
6. The composition of any of the above claims, wherein the composition
20 comprises 1.0 wppm or less of oxygen, or wherein the composition comprises 10 wppm or less of sulfur, or a combination thereof.
7. The composition of any of the above claims, wherein the composition comprises a final boiling point of 340°C or less, or wherein the composition comprises a T90 distillation point of 310°C or less, or a combination thereof.
- 25 8. The composition of any of the above claims, wherein the composition comprises 90 wt% or more of compounds having C17 – C20 carbon chains.
9. A blended composition, comprising: 1.0 wt% to 99 wt% of a distillate boiling range composition according to any of Embodiments 1 – 8; and 1.0 wt% to 99 wt% of one or more distillate fractions, one or more resid fractions, or a combination thereof.

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10. The blended composition of claim 9, wherein the blended composition comprises a T10 distillation point of 170°C or more and a T90 distillation point of 370°C or less.

11. The blended composition of claim 9, wherein the blended composition
5 comprises a T90 distillation point of 500°C or more.

12. The blended composition of any of claims 9 to 11, wherein the blended composition comprises 10 wt% to 90 wt% of the distillate boiling range composition.

13. The blended composition of any of claims 9 to 12, wherein the blended composition comprises one or more distillate fractions, the blended composition comprising
10 25 wt% or more of the distillate boiling range composition, a cloud point of the blended composition being lower than a cloud point of the one or more distillate fractions.

14. The blended composition of any of claims 9 to 13, wherein the one or more distillate fractions, one or more resid fractions, or a combination thereof comprise at least one of a bio-derived fraction and a Fischer-Tropsch fraction.

15. Use of the composition of any of claims 1 to 8 in a heat transfer fluid, a coolant, a process oil, an agricultural chemical, a dielectric fluid, an adhesive, a sealant, a printing ink, or a demolding oil.