

MIDDLE DISTILLATE FUEL FROM ORGANIC MATERIAL OF BIOLOGICAL ORIGIN

FIELD OF THE INVENTION

The present invention relates to a middle distillate fuel composition produced from organic material of biological origin, in particular organic material of biological origin comprising a high amount of impurities. Middle distillate fuels are in essence a composition of various hydrocarbons. When the source of the hydrocarbons that constitute the composition comes from biological origin, the fuel can be called renewable fuel. The present invention relates to a renewable fuel with specific fuel properties. The invention also relates to a method for producing a middle distillate fuel composition.

BACKGROUND OF THE INVENTION

Various oils and fats have been used as feedstock in production of middle distillate components suitable as fuels especially for diesel engines. The purpose of using renewable and recycled organic material of biological origin in production of fuel components is mainly to reduce the use of fossil based feedstock and thereby to tackle global warming and other environmental issues. Hydrogenated vegetable oil (HVO) is a promising alternative to fossil based middle distillate fuels. Although HVO is mainly produced from vegetable oils, also other sources such as animal fats and algae oils can be used. There is still a need for alternative non-fossil based sources and processes to produce especially middle distillate fuels.

Many organic material sources that could be used to produce hydrocarbon components, contain high amounts of impurities such as nitrogen, silicon, chloride and phosphorous containing compounds and metals. These and other impurities weaken the possibility of many organic materials to be used as feedstock or lowers the quality of the products.

Many previous methods have suggested various pre-treatment and purification processes for feedstock containing high amounts of impurities. There is also a need for new overall processes to handle feedstock with high amounts of impurities, as well as other feedstock.

BRIEF DESCRIPTION OF THE INVENTION

An object of the present invention is thus to provide a new middle distillate fuel composition produced from organic material of biological origin, especially using challenging feedstock containing high amounts of impurities and/or

chemically challenging materials like crude tall oil (CTO) optionally including tall oil pitch (TOP) or tall oil pitch (TOP). Even though the composition is produced from low quality feedstock with high levels of impurities and/or chemically challenging materials, the composition obtainable from the process according to the invention meets standard EN590:2017 requirements and MK1 specification, which meets Swedish standard SS 155435:2016. The objects of the invention are achieved by a product characterized by what is stated in the independent claim. The preferred embodiments of the invention are disclosed in the dependent claims.

DETAILED DESCRIPTION OF THE INVENTION

10 The present invention provides a middle distillate fuel composition obtainable from organic material of biological origin.

As used herein the term "organic material of biological origin" refers to organic material, i.e. material containing carbon. The organic material is of biological origin, i.e. from natural resources and is here meant to exclude fossil based organic material. Organic material of biological origin as herein used can also be renewable material. The organic material suitable for the present invention is crude tall oil (CTO) optionally including tall oil pitch (TOP) or tall oil pitch (TOP).

Specifically, the present invention provides a middle distillate fuel composition obtainable from crude tall oil (CTO) optionally including tall oil pitch or tall oil pitch (TOP) , the composition comprising

- n- and i-paraffins in an amount of 55 wt.% to 70 wt.%, of which i-paraffins content is equal to or more than 80 % of the total paraffin amount,
 - cycloalkanes in an amount of 30 wt.% to 40 wt.%, and
 - C7-C20 aromatics in an amount of 0.1 wt.% to 5 wt.%,
- 25 wherein cetane number of the fuel composition is at least 60 measured according to standard EN15195:2014 and density of the fuel composition is at least 800 kg/m³, measured according to standard ISO 12185-1996 at 15 °C.

The composition according to the present invention can with favour be used as a middle distillate fuel. A middle distillate fuel is here referring to any liquid fuel, which is especially suitable as diesel fuel. Fuels need to meet certain standards, and the composition according to the present invention preferably fulfils the EN590:2017 requirements or MK1 specification that meets Swedish standard SS155435:2016.

The composition according to the invention comprises n- and i-paraffins in an amount of 55 wt.% to 70 wt.%, preferably 60 wt.% to 65 wt.% or more

preferably 60 wt.% to 64 wt.%. Paraffins are hydrocarbons with a carbon chain of various lengths, and in n-paraffin (normal paraffins) the carbon chain is straight (non-branched) and in i-paraffins (isomerised paraffins) the carbon chain is branched. The amount of i-paraffins in the composition is equal to or more than 80 wt.% of the total paraffin content. Preferably the amount of i-paraffins is equal to or more than 90 wt.% such as 92 wt.% or more preferably equal to or more than 95 wt.%.

In one embodiment of the invention 40 wt.% to 65 wt.% of n- and i-paraffins have a carbon chain length of C14 – C19 and 0.1 wt.% to 15 wt.% of n- and i-paraffins have a carbon chain length equal to or longer than C20.

In one embodiment of the invention 65 wt.% to 75 wt.% of n- and i-paraffins have a carbon chain length of C8 – C18, and 25 wt.% to 35 wt.% of n- and i-paraffins have a carbon chain length of C19 – C26.

The current composition further comprises cycloalkanes in an amount of 30 wt.% to 40 wt.%, preferably 34 wt.% to 38 wt.% or more preferably 34 wt.% to 36 wt.%. Cycloalkanes are also called naphthenes and are cyclic hydrocarbons with the general formula of C_nH_{2n} .

In addition to paraffins and cycloalkanes the current composition further comprises C7-C20 aromatics in an amount of 0.1 wt.% to 5 wt.%, preferably 2 wt.% to 3.5 wt.%.

It has surprisingly been found that with the composition according to the invention high quality fuel properties can be achieved. The composition has a cetane number of at least 60, preferably at least 63, and more preferably at least 65 and a density in the range from 800 kg/m³ to 845 kg/m³, such as 810 kg/m³ to 830 kg/m³.

It has been found that a middle distillate fuel with improved fuel properties, especially improved cold properties, can be obtained from organic material of biological origin, comprising crude tall oil optionally including tall oil pitch or consisting tall oil pitch. The middle distillate fuel composition has a relatively low amount of n- and i-paraffins (55-70 wt.%), from which paraffins a significant amount, i.e. equal to or more than 80 wt.%, are isomerised paraffins (i-paraffins). In addition, the amount of cycloalkanes in the middle distillate fuel composition is relatively high (30 – 40 wt.%). This unique combination of paraffins and cycloalkanes in the described proportion gives superior middle distillate fuel properties. The proportion of paraffins and cycloalkanes provides a composition with at least the following fuel properties: sufficient cetane number and density (cetane number

at least 60 and density at least 800 kg/m³), but also improved cold properties, such as cloud point and/or cold filter plugging point (CFPP).

The fuel composition of the present invention is obtainable by a process comprising the steps:

- 5 - providing a feedstock comprising crude tall oil (CTO) optionally including tall oil pitch (TOP) or tall oil pitch (TOP),
- pre-treating the feedstock to obtain a purified feedstock,
- subjecting the purified feedstock to pre-hydrotreatment to obtain a partly hydrotreated feed,
- 10 - distilling the partly hydrotreated feed to obtain at least heavy bottom fraction, which is removed from the process and a middle distillate fraction, which is subjected to further process steps,
- subjecting the middle distillate fraction to further process steps comprising at least a hydrotreatment step and an isomerisation step and optionally a
- 15 fractionation or stripping step, to obtain the fuel composition.

The present invention also provides a method for producing a middle distillate fuel composition according to the invention, the method comprising

- a) providing a feedstock comprising crude tall oil (CTO) optionally including tall oil pitch (TOP) or tall oil pitch (TOP),
- 20 b) pre-treating the feedstock in one or more pre-treatment stages to obtain a purified feedstock,
- c) subjecting said purified feedstock to pre-hydrotreatment to obtain a stream of partly hydrotreated feed,
- d) distilling the stream of partly hydrotreated feed to obtain at least two
- 25 fractions, a first heavy bottom fraction, which is removed from the process and a second middle fraction, which is collected for further treatment,
- e) subjecting the collected middle fraction to hydrotreatment to obtain a stream of hydrocarbons, and
- f) subjecting the stream of hydrocarbons to isomerisation to obtain a
- 30 middle distillate fuel composition according to the invention.

Optionally the method can further comprise a fractionation or stripping step after the isomerisation, to obtain the middle distillate fuel composition.

In an embodiment of the present invention organic material of biological origin used as feedstock is selected from a group consisting of crude tall oil (CTO), tall oil pitch (TOP), tall oil fatty acid (TOFA), crude fatty acid (CFA), and distilled tall oil (DTO); more particularly the organic material of biological origin is

crude tall oil (CTO) or tall oil pitch (TOP).

In addition, the organic material of biological origin can also comprise acid oils, such as acidulated soapstock (ASK), technical corn oil (TCO), plant oil from plants of the family Brassicaceae (carinata oil), palm effluent sludge (PES) also known as palm oil mill effluent (POME), used cooking oil (UCO), gutter oil and brown grease (BG). In one embodiment the feedstock is tall oil pitch (TOP).

Crude tall oil (CTO) is most frequently obtained as a by-product of either Kraft or Sulphite pulping processes and tall oil pitch (TOP) is the residual bottom fraction from crude tall oil distillation processes. Tall oil pitch (TOP) typically comprises from 34 to 51 wt.% free acids, from 23 to 37 wt.% esterified acids, and from 25 to 34 wt.% unsaponifiable neutral compounds of the total weight of the tall oil pitch.

The method according to the present invention comprises one or more pre-treatment stages to obtain a purified feedstock. The pre-treatment stages vary and are selected based on the feedstock and especially on the amount and type of impurities in the feedstock. The pre-treatment stages can be selected from heat treatment optionally followed by evaporation of volatiles; heat treatment with adsorbent (HTA) optionally followed by flash evaporation; degumming; bleaching or any combination thereof. The pre-treatment also typically comprises a step of removing impurities from the feedstock, including any suitable removal of solids from a liquid, including filtration, centrifugation and sedimentation; and removing volatiles from liquid, e.g. by evaporation. In the pre-treatment the feedstock comprising organic material of biological origin, as previously defined, is purified and a purified feedstock is obtained.

In one embodiment the pre-treatment is selected from heat treatment with adsorbent (HTA) optionally followed by flash evaporation. HTA as pre-treatment is especially suitable when the feedstock comprises CTO and/or TOP, but also for other feedstock. Heat treatment with adsorbent (HTA) can be performed in a temperature from 180 °C to 325 °C, preferably from 200 °C to 300 °C, more preferably from 240 °C to 280 °C, optionally in the presence of an acid. The adsorbent can be selected from alumina silicate, silica gel and mixtures thereof and is typically added in an amount of 0.1 wt.% to 10 wt.%, such as 0.5 wt.%. An example of HTA can be found in WO 2020/016410.

In one embodiment the pre-treatment is selected from bleaching. Bleaching can be conducted by acid addition in an amount of from 500 to 5000 ppm based on feed. The bleaching treatment can be performed in a temperature from

60 °C to 90 °C and including a drying step in 110 °C to 130 °C. The bleaching is finished by a filtration step to remove formed solids and possible filter aids. In one example bleaching includes the following sequence

- (1) acid addition 1000-4000 ppm citric acid (50% water) 85 °C, 10 min;
- 5 (2) adsorbent/filter aid addition 0.1-1 wt.%, 85 °C, 800 mbar (80 kPa), 20 min;
- (3) drying 120 °C, 80 mbar (8 kPa), 25 min
- (4) filtering 120 °C, 2.5bar (250 kPa).

Both heat treatment (HT) and heat treatment with adsorbent (HTA) can be performed under pressure, the pressure can be 500 to 5000 kPa. Also water can be added before or during HT and HTA to a level of up to 5 wt.%, such as 1 wt.% - 3 wt.%. The evaporation, e.g. performed by flashing can be performed after HT or HTA or any other pre-treatment stage and can be performed at about 160 °C, such as from 150 °C to 225 °C, in a pressure of 10 to 100 mbar (1 to 10 kPa).

15 In one embodiment the pre-treatment comprises bleaching. In one embodiment the pre-treatment comprises heat treatment (HT), flashing and bleaching.

In one embodiment of the invention the pre-hydrotreatment is performed in conditions selected from:

- 20 - a temperature range of 300 °C to 380 °C, preferably of 320 °C to 360 °C;
- a pressure range of 40 to 100 bar, preferably 40 to 80 bar, more preferably 50 to 70 bar;
- a weight hourly space velocity (WHSV) of 0.2 1/h to 10 1/h, preferably 0.25 1/h to 10 1/h, more preferably 0.3 1/h to 8 1/h; and
- 25 - a H₂/oil feed of 800 dm³/dm³ to 1200 dm³/dm³, preferably of 900 dm³/dm³ to 1100 dm³/dm³.

The catalyst used in the pre-hydrotreatment step is a typical hydrotreating catalyst such as Ni, Co, Mo, W or any combination thereof on a carrier such as alumina. Alternatively or in addition the catalyst in pre-hydrotreatment can also be a typically hydrocracking catalyst such as NiW on acidic supports (ASA, Zeolites). In one embodiment the catalyst in the pre-hydrotreatment is NiMo on alumina carrier. The pre-hydrotreatment step is typically carried out in a reactor with one or more catalyst beds. In one embodiment, the pre-hydrotreatment is carried out in a fixed bed reactor. The extent of the pre-hydrotreatment depends on the organic material and level of impurities. The aim of the pre-hydrotreatment is to

prepare the feed, e.g. to remove heteroatoms and other impurities, to such a level that the hydrotreatment can remove the rest of the heteroatoms and impurities prior to the isomerisation.

5 The pre-hydrotreatment step is meant to remove a major part of the heteroatoms and those other impurities still left after the pre-treatment. In one embodiment of the present invention the amount of nitrogen can be removed by at least 60 wt.% and oxygen by at least 80 wt.% in the partly hydrotreated feed compared to the purified feedstock entering the pre-hydrotreatment step. These high levels of removal of heteroatoms and impurities shows that a major part of the re-
10 moval takes place in pre-hydrotreatment compared to the hydrotreatment step. Thereby, more adverse effect, such as formation of water and ammonia and catalyst de-activation, takes place in the pre-hydrotreatment step. The catalyst in the pre-hydrotreatment can be changed frequently, while the catalyst in the hydrotreatment step stays fresh. This arrangement enables one to avoid a total shut
15 down due to a catalyst change and still be able to continue production using either the mere hydrotreating catalyst, or a combination of a spare pre-hydrotreatment unit together with the hydrotreatment unit. Also, fresh hydrogen can be introduced to the hydrotreatment step, which enables highly efficient conversion. Since major part of the conversion takes place in pre-hydrotreatment, the hydrotreatment step
20 can be controlled such that the hydrotreated product is of high quality.

In the pre-hydrotreatment the partly hydrotreated feed withdrawn from the reactor can be recycled in a relatively high ratio. The ratio of recycled partly hydrotreated feed to fresh purified feedstock in the pre-hydrotreatment step can be from 1:1 to 15:1, preferably 1:1 to 10:1 and more preferably 1:1 to 5:1.

25 The method further comprises distilling to obtain at least two fractions. The two fractions are a first heavy bottom fraction and a second middle fraction. The first heavy bottom fraction is typically removed from the present method and the middle fraction is collected and subjected to further treatments. The first heavy bottom fraction can be characterized such that at least 90% of the components
30 (compounds) of the first heavy bottom fraction have a boiling point of 360 °C or above. The second middle fraction can be characterized such that at least 90 % of the components (compounds) of the second middle fraction have a boiling point of from 180 °C to 360 °C. All boiling points are given in atmospheric pressure. The first heavy bottom fraction can be used as a product as such or subjected to other
35 processes (not disclosed here).

In one embodiment the distillation is performed using the following

conditions: a cut point target of 340 °C to 360 °C, vacuum set point of 2 mbar (0.2 kPa), top column temperature of 180 °C, nitrogen feed rate of 2 l/h and feed rate of 0.24 l/h. These conditions are to be regarded as examples and a skilled person is able to operate the distillation such that the target fractions are obtained.

5 The process of the present invention further comprises subjecting the collected middle fraction to hydrotreatment to obtain a stream of hydrocarbons and subjecting the stream of hydrocarbons to isomerisation to obtain an isomerised stream of hydrocarbons.

10 in one embodiment of the invention the hydrotreatment is performed in conditions selected from:

- a temperature range of 300 °C to 380 °C, preferably of 320 °C to 360 °C;
- a pressure range of 40 to 100 bar, preferably 40 to 80 bar, more preferably 50 to 70 bar;
- 15 - a weight hourly space velocity (WHSV) of 0.25 1/h to 1.5 1/h, preferably 0.3 1/h to 1 1/h, and
- a H₂/oil feed of 800 dm³/dm³ to 1200 dm³/dm³, preferably of 900 dm³/dm³ to 1100 dm³/dm³.

20 The catalyst used in the hydrotreatment step is a typical hydrotreating catalyst such as Ni, Co, Mo, W or any combination thereof on a carrier such as alumina. Alternatively or in addition, the catalyst in the hydrotreatment can also be a typically hydrocracking catalyst such as NiW on acidic supports (ASA, Zeolites). In one embodiment the catalyst in the hydrotreatment is NiMo on alumina carrier. The treatment step is typically carried out in a reactor with one or more catalyst
25 beds.

 In the hydrotreatment the stream of hydrocarbon withdrawn from the reactor can be recycled back to the hydrotreatment. If there is recycling in the hydrotreatment step, the amount of recycled material is very low. In an embodiment a maximum of 10 wt.% of the stream of hydrocarbons is recycled back to hydrotreatment. In one embodiment the hydrotreatment step does not contain any
30 recycling.

 The aim of the hydrotreatment is to essentially remove all impurities and heteroatoms from the feed, and the stream of hydrocarbons should therefore essentially only contain hydrocarbons.

35 In one embodiment of the present invention, the isomerisation of the

stream of hydrocarbons to obtain a stream of isomerised hydrocarbons is performed in conditions selected from:

- a temperature range of 300 °C to 360 °C, preferably 310 °C to 345 °C;
- 5 - a pressure range of 35 bar to 60 bar, preferably 40 bar to 50 bar;
- a weight hourly space velocity (WHSV) of 1 1/h to 1.5 1/h.

The catalyst used in the isomerisation of the stream of hydrocarbons is any typical isomerisation catalyst, such as Pt or Pd on a suitable support, preferably the isomerisation catalyst is Pt-SAPO11.

10 In one embodiment of the present invention the process further comprises a stripping step to remove gaseous compounds from a stream of the process. The stripping step can be performed after the pre-treatment step, the pre-hydrotreatment step, the hydrotreatment step, the isomerisation step or any combination thereof. In one embodiment the stripping is performed after the pre-hydrotreatment step to remove gaseous compounds before the distillation step. Gas-
15 eous compounds which can be removed in a stripping step include sulphide (H₂S), ammonia (NH₃) and water. The stripping step can also be called a flash step or flash evaporation or flash distillation.

20 EXAMPLE 1

A feed of crude tall oil (CTO) including tall oil pitch (TOP) was purified by bleaching in a pre-treatment stage. The purified feed was subjected to a pre-hydrotreatment step using a NiMo catalyst. The conditions of the pre-treatment step were as follows: a temperature of 350 °C, a pressure of 60 bar (6000 kPa) and
25 WHSV 0.5 1/h. The thus obtained partly hydrotreated stream was subjected to a distillation step, using a cut point of 340 - 360 °C. The heavy fraction (boiling above cut point of 340 - 360 °C) was removed and the middle fraction (boiling up to 340 -360 °C) was collected and subjected to a hydrotreatment step.

The hydrotreatment of the collected middle fraction was performed in
30 the following conditions: a temperature of 335 °C, a pressure of 50 bar (5000 kPa) and WHSV of 0.5 1/h. The catalyst used was a NiMo catalyst.

After the hydrotreatment step the hydrotreated feed was subjected to an isomerisation step. The isomerisation was conducted in the following conditions: a fixed bed reactor containing platinum oxide on porous silica-alumina support as the isomerisation catalyst, WHSV was fixed at 1.5, and pressure at 40 bar
35 (4000 kPa). Runs were performed at 300 n-L/L H₂ to oil ratio, and the temperature

ranged from 338 °C to 342 °C.

The products obtained were collected and properties were analysed. The summary of the compositions of hydrocarbon products can be seen in Table 1. Also the fuel properties of the hydrocarbon compositions (Summer grade and Winter grade) were measured. Comparison of density, cloud point, cold filter plugging point (CFPP) and cetane number in respect to standard EN590 and MK1 specification and methods used can be seen in Table 2.

Table 1. Composition of products (GCxGC-MS)

	Summer grade	Winter grade
n-paraffins, wt.%	8.97	2.66
iso-paraffins, wt.%	52.62	61.68
iP-me	40.54	24.95
iP-dime	11.83	33.28
iP-trime	0.18	3.29
naphthenes, wt.%	38.09	34.44
aromatics, wt.%	0.32	1.23

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Decreased amount of n-paraffins decreases cetane index. Increasing aromatic and naphthene amounts increase the density of the products. The results show that the produced hydrocarbon compositions have fuel properties making them suitable as a diesel fuel component or as a diesel fuel as such. The cetane number and density of the produced hydrocarbon compositions e.g. satisfies standard EN590:2017 and MK1 specification. Furthermore, the cold properties are good.

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Table 2. Fuel properties of the middle distillate product produced compared to standard EN 590 and MK1 specification

Property	Method	Unit	Summer grade	Winter grade	EN590	MK1
Density 15°C	EN ISO 12185: 1996	kg/m ³	822.3	819.2	800-845	800-830
Cloud point	ASTM D7689: 2021	°C	-10.5	-32	grade / e.g. class 3 -28	
CFPP	EN 116: 2015	°C	-9	-31	grade / e.g. class 3 -38	winter -26
Cetane number IQT	EN15195 :2014		69.1	62.8	min 51	min 51

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EXAMPLE 2

A feed of tall oil pitch (TOP) was subjected to a pre-treatment step including heat treatment, flashing and bleaching, to remove impurities.

The purified feed was subjected to a pre-hydrotreatment step in the following conditions: temperature 350 °C, pressure 50 bar WHSV 0.33 1/h, H₂/Oil 1000 dm³/dm³ and using a NiMo catalyst on alumina carrier. The ratio of fresh feed to recycled partly hydrotreated feed was 1:12.

The thus partly hydrotreated feed was distilled with a cut point of 340 – 360 °C, and vacuum set point of 2 mbar. After the distillation the 340 to 360 °C fraction was subjected to hydrotreatment in the following conditions: temperature 350 °C, pressure 50 bar (5000 kPa), WHSV 0.33 1/h, H₂/Oil 1000 dm³/dm³ and using a NiMo catalyst on alumina carrier

After the hydrotreatment, the hydrotreated feed was isomerised in two different temperatures; ISOM1 in 328 °C, pressure 42 bar (4200kPa), WHSV 1.5 1/h and ISOM2 in 334 °C, pressure 42 bar (4200kPa), WHSV 1.5 1/h.

The products obtained were collected and their properties were analysed. The compositions of hydrocarbons products obtained using both isomerisation conditions ISOM1 and ISOM2 can be seen in Table 3.

Also a reference product was produced using 100 % animal fat (AF) feed and the same process as for ISOM1 and ISOM2 products. The isomerisation temperature was 327°C. The composition of the reference hydrocarbon product can be seen in Table 3.

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Table 3. Composition of products (GCxGC-MS)

	ISOM 1	ISOM 2	Reference
ISOM Temperature, °C	328	334	327
n-paraffins, wt. %	3.66	3.28	5.39
iso-paraffins, wt. %	57.62	57.97	93.99
iP-me	26.76	20.73	35.50
iP-dime	27.84	30.70	55.24
iP-trime	2.28	4.89	3.17
naphthenes, wt. %	36.22	35.33	0.61
aromatics, wt. %	2.49	3.42	0

10 The fuel properties of the hydrocarbon compositions (ISOM1, ISOM2, Reference) were measured. Comparison of density, cloud point, cold filter plugging point (CFPP) and cetane number in respect to standard EN590 and MK1 specification can be seen in Table 4.

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Table 4. Fuel properties of the produced middle distillate products (ISOM1, ISOM2, Reference) compared to standard EN 590 and MK1 specification

Prop-erty	Method	Unit	ISOM1	ISOM2	Ref.	EN590	MK1
Density 15°C	ENISO 12185: 1996	kg/m ³	819.4	816.7	778.2	800-845	800-830
Cloud point	ASTM D7689: 2021	°C	-32.8	-39.2	-36.9	grade / e.g. class3 -28	
CFPP	EN 116 - 2015	°C	-34	-38	-40	grade / e.g. class3 -38	Winter -26
Cetane number IQT	EN15195:2014		62.5	65.4	76.5	min 51	min 51

Results of the examples show that the hydrocarbon composition has fuel properties making it suitable as a renewable diesel fuel component or as a renewable diesel fuel as such. The cetane number and density e.g. satisfies standard EN590:2017 and MK1 specification while the reference sample does not. Further, the obtained products had good cloud point values, below -30 °C. Swedish standard SS 155435:2016 allows quite high aromatic content (max 5 % (v/v)). The products (ISOM1 and ISOM2) of Example 2 meet requirements of MK1 specification (Swedish standard SS 155435:2016). Also the maximum viscosity limit in the MK1 specification can be met with slightly higher isomerisation temperature, as used in ISOM2 product. The benefits when using TOP product as a bio component or as a fuel as such include good cold properties, in regard to both cloud point and cold filter plugging point, and cetane number, density and aromatic content that all would fit well into MK1 specification.

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

CLAIMS

1. A middle distillate fuel composition obtainable from crude tall oil (CTO) optionally including tall oil pitch (TOP) or tall oil pitch (TOP), the composition comprising
- 5 - n- and i-paraffins in an amount of 55 wt.% to 70 wt.%, of which i-paraffins content is equal to or more than 80 % of the total paraffin amount,
- cycloalkanes in an amount of 30 wt.% to 40 wt.%, and
- C7-C20 aromatics in an amount of 0.1 wt.% to 5 wt.%,
- wherein cetane number of the fuel composition is at least 60 and density of the middle distillate fuel composition is at least 800 kg/m³.
- 10 2. The middle distillate fuel composition of claim 1, wherein the cetane number is at least 62, and more preferably at least 65.
3. The middle distillate fuel composition of claim 1 or 2, wherein the density of the middle distillate fuel composition is from 800 kg/m³ to 845 kg/m³,
- 15 preferably from 810 kg/m³ to 830 kg/m³.
4. The middle distillate fuel composition of any of the preceding claim, wherein 40 wt.% to 65 wt.% of n- and i-paraffins have a carbon chain length of C14-C19, and 0.1 wt.% to 15 wt.% of n- and i-paraffins have a carbon chain length equal to or longer than C20.
- 20 5. The middle distillate fuel of any of preceding claim, wherein the composition comprises
- n- and i-paraffins in an amount of 60 wt.% to 64 wt.%, of which i-paraffins content is equal to or more than 90 % of the total paraffin amount,
- cycloalkanes in an amount of 34 wt.% to 36 wt.%, and
- 25 - C7-C20 aromatics in an amount of 2 wt.% to 3.5 wt.%.
6. The middle distillate fuel composition of any of the preceding claim, wherein the fuel composition is obtained from tall oil pitch (TOP).
7. The middle distillate fuel composition of any of the preceding claim, wherein the middle distillate fuel composition is obtainable by a process comprising the steps:
- 30 - providing a feedstock comprising crude tall oil (CTO) optionally including tall oil pitch (TOP) or tall oil pitch (TOP),
- pre-treating the feedstock to obtain a purified feedstock,
- subjecting the purified feedstock to pre-hydrotreatment to obtain a
- 35 partly hydrotreated feed,
- distilling the partly hydrotreated feed to obtain at least a heavy bottom

fraction, which is removed from the process and a middle distillate fraction, which is subjected to further process steps,

- subjecting the middle distillate fraction to further process steps comprising at least a hydrotreatment step and an isomerisation step and optionally a fractionation or stripping step, to obtain the middle distillate fuel composition of any of claim 1 – 6.

8. A method for producing a middle distillate fuel composition according to claim 1 to 7, the method comprising

- a) providing a feedstock comprising crude tall oil (CTO) optionally including tall oil pitch (TOP) or tall oil pitch (TOP),
- b) pre-treating the feedstock in one or more pre-treatment stages to obtain a purified feedstock,
- c) subjecting said purified feedstock to pre-hydrotreatment to obtain a stream of partly hydrotreated feed,
- d) distilling the stream of partly hydrotreated feed to obtain at least two fractions, a first heavy bottom fraction, which is removed from the process and a second middle fraction, which is collected for further treatment,
- e) subjecting the collected middle fraction to hydrotreatment to obtain a stream of hydrocarbons, and
- f) subjecting the stream of hydrocarbons to isomerisation to obtain a middle distillate fuel composition according to any of claims 1 to 7.

9. The method of claim 8, wherein the method further comprises a fractionation or stripping step after the isomerisation, to obtain the middle distillate fuel composition according to any of claims 1 to 7.