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(54) Title: RENEWABLE HEATING OIL

(57) Abstract: A use of a fuel comprising renewable hydrotreated fuel as a heating oil is provided. The renewable hydrotreated fuel has good cold properties and it can be blended with conventional heating oils, thus making it suitable for domestic use.

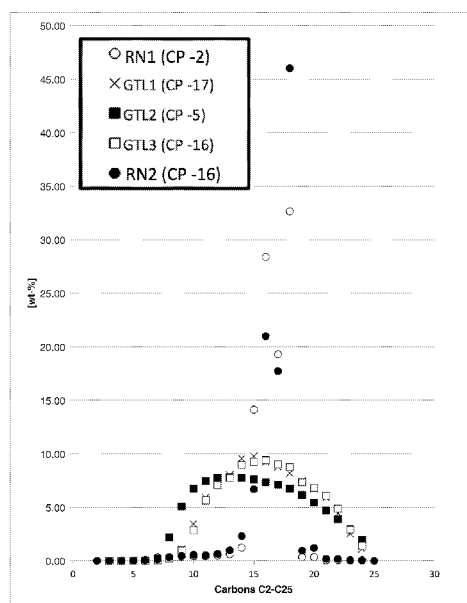


Fig. 1

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RENEWABLE HEATING OIL

Field of the invention

The present invention relates to renewable heating fuels.

5 Background

Environmental interests drive fuel producers to employ more intensively renewable sources in the manufacture of fuels, such as heating oils. Thus, novel renewable fuels are needed to meet requirements set by regulations and renewable fuel standards. Further, there is a need to identify such fuels.

10 Previous renewable heating oils have comprised e.g. fatty acid methyl ester (FAME) based fuels called biofuels or traditional biofuels. Such fuels are sensitive to aging and have poor cold properties. Renewable heating oil compositions comprising vegetable oil as such and a petroleum fraction rich in aromatic compounds are also known from prior art.

15 Previous attempts for using paraffinic heating oils failed because of malfunction of the burner. For example WO2008138861 discloses a paraffinic fuel, which needs aromatic or conjugated hydrocarbons to be suitable for use in domestic heating appliances.

A possible approach to produce renewable heating oils is to use gas-to-liquid
20 (GTL) methods having biomethane or natural gas as a raw material.

Hydrogenated vegetable oil (HVO) is a renewable fuel produced from renewable sources. HVO can be produced from vegetable oils by hydrogenating the fatty acids and triglycerides therein into n-paraffins optionally followed by catalytic conversion into branched paraffins (i-paraffins). The manufacturing process of
25 HVO aims keeping the saturation level high and avoiding formation of aromatic compounds. Double bonds in unsaturated free fatty acids may promote various side reactions, such as oligomerisation / polymerisation, cyclisation / aromatisation and cracking reactions.

An object of the invention is to provide a renewable fuel, which can be used in
30 heating.

SUMMARY

The present invention provides a use of a fuel comprising renewable hydrotreated fuel as a heating oil.

An advantage of the renewable hydrotreated fuel in heating oil use is that it has a
5 low aromatic content or it may even be free from aromatics. Because of that, it burns cleanly and produces less soot when burned. Thus, by using the present renewable hydrotreated fuel as a heating oil, improved burning properties of a heating oil can be obtained, which helps to keep burning systems and chimneys clean. The heat value (energy content) of the renewable hydrotreated fuel is
10 better than the heat value of fossil fuel. The renewable hydrotreated fuel has also a higher energy content compared to traditional biofuels. The energy is released during combustion into a usable form, heat.

Further, the use of the present renewable hydrotreated fuel as a heating oil provides improved safety, because of the low amount, or even absence, of
15 aromatic hydrocarbons in the fuel. Aromatic hydrocarbons, such as PAH, present in fossil fuels are toxic and linked to serious health issues, like cancer. In particular in domestic heating the lack of aromatics in the heating oil is advantageous because exposure to harmful compounds e.g. during maintenance and refilling can be avoided.

20 Further, when using the renewable hydrotreated fuel as a heating oil renewable components are used and thus an environmentally sustainable heating method is achieved. Use of fossil fuels in heating can be diminished or even omitted. With the present invention, it is possible to achieve heating, which meets technical requirements, future biomandates, and consumer needs for renewable and
25 environmentally friendly fuels.

Thus, it is an object of the present invention to provide a renewable heating oil, which meets technical requirements of renewable fuels. Previously renewable heating oils have not been used in burners because of problems relating to flame detection. The present invention provides a technical solution to this problem and
30 achieves desired environmental aspects.

The use of the renewable hydrotreated heating oil is particularly advantageous for domestic users because the fuel composition lacks a distinctive unpleasant

odour typical for heating oils. This makes e.g. maintenance of the heating system and refilling fuel storages more pleasant. The unpleasant odour of heating oils has previously been masked by using odorants, which can be avoided with the fuel composition of the present invention. However, an odorant can optionally be
5 used with the present heating oil, if desired.

It was surprisingly found by the inventors that the renewable hydrotreated fuel of the present invention can be used as a heating oil in conventional domestic burners adapted to burn fossil fuel even without additional components or modifications. This is particularly advantageous in domestic use for those users
10 who want to use renewable fuels in heating but are reluctant to invest in a burner specifically optimized for renewable heating oils. Thus, the present use is applicable in conventional burners without modifications, as well as in conventional burners that have been modified.

The heating oil of the present invention can also be fully renewable. The
15 renewable hydrotreated heating oil comprising 100% renewable hydrotreated fuel can also be burned in a conventional domestic burner without additional components or modifications.

According to one embodiment the present invention can also be used as an energy source in hybrid heating systems, like heating systems comprising electric
20 heating, air to air heat pump or solar panels.

Further advantages include good stability and cold properties of the present renewable hydrotreated fuel. As evidenced by the Examples, the present renewable hydrotreated fuel has ASTM D7689:2012 Cloud Point of below -30 °C, which makes it suitable for use in very cold climate or even in an arctic
25 environment. In an embodiment the use comprises using the present fuel at a temperature below -10 °C. In another embodiment said use comprises storing the fuel without additional heating of the fuel.

Good cold performance is important because in domestic use heating oil is typically stored in storage tanks or containers in varying temperatures for
30 extended time periods. The storage containers may be located at least partially underground or above ground. Such containers are exposed to the temperatures typical for the external storage environment. In particular at cold climate the

containers are exposed to very low temperatures, wherein the present fuel is particularly advantageous, because of the excellent cold properties of the fuel that allow storing the outdoors.

BRIEF DESCRIPTION OF THE FIGURES

5 Fig. 1 shows the profile of paraffinic components for the renewable hydrotreated heating oil (RN1, RN2), and GTL fuels. CP refers to Cloud Point.

Fig. 2 shows a detailed distribution of paraffinic components in the renewable hydrotreated heating oil and a GTL fuel.

DETAILED DESCRIPTION OF THE INVENTION

10 In an embodiment the renewable hydrotreated fuel comprises a paraffinic component obtained by hydrotreating and isomerising renewable material having biological origin.

In an embodiment the present renewable hydrotreated fuel is isomerised to have a weight ratio of isoparaffins (i-paraffins) to normal paraffins (n-paraffins) at least
15 2.2, aromatic content 0.1 w-% or less and Cloud Point (ASTM D7689:2012) -10 °C or less.

The present use is advantageous in that it is safe for domestic use.

Further, the colouring agent can be selected in a way that the renewable heating oil is distinguishable from e.g. fossil fuels or from fuels intended for vehicles.
20 Thus, the colouring agent allows easy identification of the fuel and it's origin. For example, a specific colouring agent can be used as a tag to indicate a fuel complying with certain requirements, such as requirements set for renewable heating oil.

Additionally or alternatively, an agent, which provides a signal to be detected by
25 the heating system when the fuel is combusted, can also be added into the heating oil.

In an embodiment the manufacturing of the renewable hydrotreated fuel does not comprise gasifying the renewable raw material.

When preparing the renewable hydrotreated fuel, in the first step of the process
30 fatty acids, triglycerides and other fatty acid derivatives comprised in the feed are

deoxygenated, denitrogenated and desuplhurised by hydrotreatment. Hydrotreating includes at least hydrodeoxygenation (HDO) and decarboxylation / decarbonylation, i.e. removal of oxygen in the form of CO_x , as well as other catalytic processes to remove oxygen from organic oxygen compounds in the form of water, to remove sulphur from organic sulphur compounds in the form of dihydrogen sulphide (H_2S), to remove nitrogen from organic nitrogen compounds in the form of ammonia (NH_3) and to remove hydrodenitrogenation (HDN) and halogens, for example chlorine from organic chloride compounds in the form of hydrochloric acid (HCl) and hydrodechlorination (HDCI).

- 10 In the hydrotreating step, the pressure range may be varied, or is selected from the range, between 20 and 150 bar, preferably between 50 and 100 bar, and the temperature is selected from the range between 200 and 400 °C, preferably between 250 and 350 °C and most preferably between 280 and 340 °C.

In the hydrotreatment/hydrodeoxygenation step, known hydrogenation catalysts containing metals from Group VIII and/or VIB of the Periodic System may be used. Preferably, the hydrogenation catalysts are supported Pd, Pt, Ni, NiMo or a CoMo catalyst, the support being alumina and/or silica. Typically, NiMo/ Al_2O_3 and CoMo/ Al_2O_3 catalysts are used.

The hydrotreating is optionally followed by isomerisation, such as hydroisomerisation, where branches on the hydrocarbon backbone are formed and i-paraffins are produced. Typically methyl and ethyl side-chains are formed in the isomerisation step and the degree of isomerisation, e.g. the amount of methyl branches formed and their distance from each other, can be controlled by reaction conditions, such as temperature and catalyst. Isomerisation produces an improved performance for the product for low temperatures.

In the isomerisation step, the pressure varies in, or is selected from, a range of 20-150 bar, preferably in the range of 30-100 bar and the temperature varies, or is selected from, a range between 200 and 500 °C, preferably 280 and 400 °C.

In the isomerisation step, an isomerisation catalyst known in the art may be used. Suitable isomerisation catalysts contain a molecular sieve and/or metal selected from Group VIII of the Periodic Table and/or carrier. Preferably, the isomerisation catalyst contains SAPO-11 or SAPO-41 or ZSM-22 or ZSM-23 or ferrierite and

Pt, Pd, or Ni and Al_2O_3 or SiO_2 . Typical isomerisation catalysts are, for example, Pt/SAPO-11/ Al_2O_3 , Pt/ZSM-22/ Al_2O_3 , Pt/ZSM-23/ Al_2O_3 and Pt/SAPO-11/ SiO_2 .

In an embodiment the hydrotreating step and the isomerisation step are carried out separately in a two-step process. In an embodiment the hydrotreatment
5 catalyst(s) and the isomerisation catalyst(s) are not in contact with the feed at the same time.

In an embodiment the renewable hydrotreated fuel feedstock comprises hydrotreated, and optionally isomerised vegetable oil (HVO), and/or wood and/or other plant based oil, animal fat, fish fat, fish oil, algae oil, microbial oil or
10 combination thereof, and optionally recyclable waste and/or residue, or a combination thereof.

Recyclable waste comprises material such as used cooking oil, free fatty acids, palm oil by-products or process side streams, sludge, and side streams from vegetable oil processing.

15 The renewable hydrotreated fuel feedstock may comprise:

- I. one or more free fatty acid distillates, such as palm fatty acid distillate and/or soya free fatty acid distillate;
- II. one or more free fatty acid containing bio based feedstock, such as crude and refined palm based oil, technical corn oil, tall oil, seed oil, animal fat,
20 waste cooking oil, jatropha curcas oil, fish oil, microbial oil, and/or algae oil;
- III. by-products from fatty acid methyl ester and bio based chemicals production and/or oil derived from lignocellulosic biomass; and/or
- IV. one or more lower molecular weight acids containing bio based feedstock
25 such as pyrolysis oil and/or sludge palm oil.

For use at extremely low temperature, cold properties of renewable hydrotreated fuel can be improved by increasing the amount of i-paraffins by controlling the process parameters. In one embodiment fatty acids or triglycerides of the feedstock are first hydrogenated to n-paraffins, and part of the n-paraffins are
30 then converted using isomerisation to branched chain i-paraffins.

In one embodiment the weight ratio of i-paraffins to n-paraffins in the renewable hydrotreated fuel is at least 2.2, at least 2,3, at least 3 or at least 4.

In one embodiment in the renewable hydrotreated fuel the amount of the paraffinic component in the range of carbon number C₁₅-C₁₈ is at least 70 wt-%, more preferably more than 80 wt-%, most preferably more than 90 wt-%. This distribution is advantageous because there are no easily volatile light paraffinic components or heavy components that cause sooting.

Optionally, in the renewable hydrotreated fuel component the amount of the paraffinic components in the range of carbon number C₃-C₁₄ is less than 25 wt-%, such as less than 20 wt-%, less than 10 wt-%, or less than 7 wt-%. Further, optionally in the renewable hydrotreated fuel component the amount of the paraffinic components in the range of carbon number C₁₉-C₂₄ is less than 25 wt-%, such as less than 20 wt-%, less than 10 wt-%, or less than 5 wt-%. The above distribution of paraffinic components is typical for the renewable hydrotreated fuel of the present invention. The flash point is determined with the amount of the light paraffinic components and sooting is minimized with the amount of heavier components. The renewable hydrotreated fuel has good cold and storage properties and heat value. That is why the renewable hydrotreated fuel is a suitable component to be used in a heating oil.

The narrow distribution of paraffinic hydrocarbons in the range C₁₅-C₁₈ is typical for the present renewable hydrotreated heating oil and distinguishes it from previous heating oils. For example, heating oils manufactured from natural gas or biogas by GTL process have a much broader distribution of paraffinic hydrocarbons. The distribution of paraffinic hydrocarbons according to the invention provides a low volatility, good heat value and good cold properties for the heating oil causing just a little or not at all sooting. The narrow distribution of the paraffinic hydrocarbons also makes the fuel well defined in its physical properties, which makes it useful for use in blends and other products.

Previous renewable fuels have been designed for use in diesel engines.

In one embodiment the heating oil of the present invention comprises renewable fuel obtainable from at least one lignocellulosic source. In that kind of embodiment the naphthenic hydrocarbons comprise compounds obtained from a

lignocellulosic source by converting levulinic acid (LA) via C-C coupling reactions in the presence of an ion exchange resin (IER) catalyst, in a thermal treatment, in the presence of a solid metal oxide catalyst system or combination thereof forming LA dimers/oligomers. A solid metal oxide catalyst system may comprise
5 the first metal oxide and the second metal oxide. Naphthenic components can be included to increase density of the renewable fuel and/or to provide aromatic components from a renewable source.

In one embodiment the renewable fuel obtainable from at least one lignocellulosic source is manufactured by hydrodeoxygenation of a feedstock
10 comprising LA dimers/oligomers, followed by fractionated distillation. The renewable fuel obtainable from at least one lignocellulosic source is advantageous for use as a heating oil, because the resulting fuel has a very low Cloud Point and it can easily be mixed with other fuels.

In one embodiment the renewable fuel obtainable from at least one
15 lignocellulosic source comprises renewable middle distillate composition and contains less than 10.0 wt.-% aromatics, as determined in accordance with ASTM D2425-04. In other embodiment the renewable fuel obtainable from at least one lignocellulosic source contains at most 9.5 wt.-%, at most 9.3 wt.-%, at most 9.0 wt.-%, at most 8.0 wt.-%, at most 7.0 wt.-%, at most 6.0 wt.-%, at most
20 5.0 wt.-%, at most 4.0 wt.-%, or at most 3.0 wt.-% of aromatics, as determined in accordance with ASTM D2425-04. In another embodiment the Cloud Point of the renewable fuel obtainable from at least one lignocellulosic source is -70°C or lower, -80°C or lower, - 90°C or lower, or -95°C or lower.

In one embodiment the heating oil optionally comprises naphthenic
25 hydrocarbons. A naphthenic hydrocarbon refers to organic compounds that contain one or more saturated cyclic structures. The general formula is C_nH_{2n} . The naphthenic hydrocarbon may be a fossil hydrocarbon, a hydrocarbon obtainable from lignocellulosic biomass, or a combination thereof.

In one embodiment the amount of the naphthenic component in the renewable
30 hydrotreated fuel of the present invention is between 2% and 90% by weight, such as between 2% and 70% by weight, between 2% and 50% by weight, or between 2% and 30% by weight, preferably between 2% and 20% by weight,

between 3% and 15% by weight, or between 3% and 12% by weight, preferably about 5% by weight or 10% by weight.

The renewable hydrotreated fuel or the present fuel can optionally comprise aromatic and polyaromatic components to increase density for use in certain
5 applications.

In one embodiment the heating oil of the present invention further comprises fossil fuel, i.e. it is a blend.

Further, in one embodiment the heating oil comprises fatty acid methyl esters (FAME).

10 It is possible to blend the renewable hydrotreated fuel in a desired amount with aromatic hydrocarbons, naphthenic hydrocarbons, a fossil fuel, and/or FAME for heating purposes. In one embodiment 100 % renewable hydrotreated fuel is used in heating applications as such, even without blending it with a fossil fuel component and/or other fuel composition that increase the responsiveness of a
15 yellow/red flame detector of a burner to a required threshold level.

In an embodiment the fuel comprises 1-100 wt-% renewable hydrotreated fuel.

It is advantageous to increase the proportion of the renewable hydrotreated and optionally isomerised fuel to achieve cleaner burning of the fuel. When used as a blend with a fossil fuel, a larger proportion of the renewable hydrotreated and
20 optionally isomerised fuel also helps to reduce harmful effects of the fossil fuel, in particular amount of aromatics and sulphur, and results into decreased emissions during use. Blending is particularly advantageous when using lower grade fossil fuel, which contains sulphur and other impurities.

In an embodiment the fuel comprises more than 40 wt-% renewable hydrotreated
25 fuel. In an embodiment the fuel comprises more than 42% renewable hydrotreated fuel, such as a 42-100 wt-%, 42-99 wt-%, 42-95 wt-%, 42-90 wt-%, 42-85 wt-% or 42-80 wt-%.

In another embodiment the renewable hydrotreated fuel comprises more than 45 wt-% renewable hydrotreated fuel, such as 45-100 wt-%, 50-100 wt-%, 55-100
30 wt-%, 60-100 wt-%, 65-100 wt-%, 70-100 wt-%, 75-100 wt-%, 80-100 wt-%, 85-100 wt-%, 90-100 wt-%, 95-100 wt-% or even 100 wt-%. These amounts of the

renewable hydrotreated fuel provide good cold properties and provide even a completely renewable heating oil. Further, if a blend is formed with the hydrotreated renewable fuel, the amount of other components can be kept low, resulting into clean combustion because of the advantageous properties of the renewable hydrotreated fuel. Typically fossil fuels contain e.g. aromatics that produce particles and soot when burned. In the claimed use this is advantageous because the burner and the heating system remain clean and operational during use.

Optionally the renewable hydrotreated fuels is isomerised, which helps to further improve cold properties by increasing the amount of branched chain hydrocarbons. For example the cloud point of the fuel is improved, which is advantageous in long term storage in a cold environment. Renewable hydrotreated fuel, which is isomerised, can be used in any embodiment of the present invention.

In an embodiment the fuel contains naphthenic and/or aromatic hydrocarbons. In an embodiment these hydrocarbons are used for further enhancing detection of the flame in a burner. Such a use may be advantageous in cases where the flame detector is not very sensitive.

In an embodiment the fuel complies with EN 15940:2016 for paraffinic diesel fuels.

In an embodiment the present heating oil comprises 10% fossil heating oil containing aromatics and 90% renewable hydrotreated fuel.

In an embodiment the present heating oil comprises 10% fossil heating oil containing naphthenics and 90 % renewable hydrotreated fuel.

In an embodiment the present heating oil comprises 10% FAME and 90% renewable hydrotreated fuel.

In an embodiment the present heating oil comprises 5% fossil heating oil containing naphthenics and 95% renewable hydrotreated fuel.

In an embodiment the present heating oil comprises 5% fossil heating oil containing aromatics and 95% renewable hydrotreated fuel.

In one embodiment the heating oil does not contain cold flow additives, such as pour point or cold flow improvers.

The use of the heating oil according to the present invention is simple, it does not need any special arrangement. The user of the heating oil according to the present invention does not need to carry out any cleaning e.g. rinsing or change filters or settings of the heating system when changing from one heating oil to another, e.g. from a fossil heating oil to the renewable hydrotreated fuel according to the invention. Thus, the heating oil of the present invention can be filled into a heating oil container even when some previously used heating oil is still present in the storage container. Similarly, other heating oil can be added in the heating oil storage container while heating oil of the present invention is still left in the container.

The term burner comprises burners, furnaces and heaters used in heating systems. Such systems are also known as boilers, heaters, fuel-burning apparatuses, or central heating systems. The burner may be configured to heat a fluid, such as liquid, gas or vapour, which is used for transferring heat to the site wherein heating is needed.

In one embodiment the heating oil is burned in a burner for heating a building, a house, workshop, industrial space, or garage.

In one embodiment the burner is equipment used for burning fossil fuel.

In one embodiment the renewable heating oil of the present invention is burned in the burner.

In one embodiment the heating oil is provided in a container exposed to environmental temperatures outdoors.

Because of the good cold properties of the renewable hydrotreated fuel, it can be stored outdoors even in cold climates without a need to heat or insulate the storage container. Thus, the fuel can e.g. be stored outdoors and conducted through piping to a burner inside a building to be heated. The container can be an above-ground container or at least partially, or fully, underground container.

The container can also be provided with insulation or a heater, which may be

advantageous when it is desirable to be able to use the same container for heating fuels that do not have as good cold flow properties.

In an embodiment the renewable hydrotreated fuel comprises at least 70 wt-%, more preferably more than 80 wt-%, most preferably more than 90 wt-%
5 paraffinic components in the range of carbon number C₁₅-C₁₈. Such a fuel has a low amount of volatile components, good cold storage properties and heat value. This is particularly advantageous when using the heating oil in a climate where temperature varies over a broad range and which may involve storing the fuel for a long time.

10 In an embodiment of the use, the renewable hydrotreated fuel is obtained from at least one lignocellulosic source. The lignocellulosic source provides the heating oil with naphthenic and aromatic components.

In an embodiment of the use the heating oil comprises hydrocarbons obtained from at least one lignocellulosic source.

15 In an embodiment a renewable hydrotreated fuels is used which has a weight ratio of i-paraffins to n-paraffins of 2.3, 2.3, 3, or 4 in the renewable hydrotreated fuel.

In an embodiment the use further comprises using naphthenic hydrocarbons in the heating oil.

20 In an embodiment the use comprises using naphthenic hydrocarbons 1-5 % by weight, 1-10% by weight, or 1-50% by weight, preferably about 5% by weight.

In an embodiment the use comprises using a renewable hydrotreated fuel having less than 10 wt-% aromatics.

In an embodiment the use comprises storage at a temperature below 0 °C, below
25 -10 °C, or below -37°C.

In an embodiment the use comprises mixing the renewable hydrotreated fuel into a blend with a fossil fuel.

In an embodiment 0-99%, 0-15% or 5-10% of fossil fuel is used in the blend with the renewable hydrotreated fuel.

30 In an embodiment a colouring agent is included in the heating oil.

In an embodiment the colouring agent is a yellow azo dye, such as Solvent Yellow 124 (N-ethyl-N-(2-(1-isobutoxyethoxy)ethyl)-4-(phenyl-azo)aniline). Additionally, one or more colouring agent, such as a red dye or a blue dye, can be used.

- 5 In another embodiment the amount of the colouring agent is at least 1 mg/l, preferably selected from the range 1-10 mg/l, and most preferably selected from the range 6-9 mg/l.

In an embodiment the colouring agent is an agent, which provides a signal to be detected by the heating system when the fuel is combusted.

- 10 In another embodiment the present use comprises including a colouring agent in the fossil fuel, in the hydrotreated renewable fuel, or in the blend comprising them. In an embodiment the colouring agents have different colours to allow identification of a composition of a blend.

In an embodiment the use comprises burning the heating oil in a heating system.

- 15 In an embodiment the use comprises using a heating system, which is a domestic heating system for heating buildings, houses, or garages, or an industrial heating system for heating workshops, industrial facilities, premises or workspaces.

- In an embodiment the use comprises using heating system, which is a heating
20 system for burning fossil fuel.

In an embodiment the heating system comprises a burner for fossil fuel.

- In an embodiment the use comprises providing the heating oil in a container, which exposes the heating oil to low temperatures. In an embodiment the low temperature is a temperature below 5°C, such as below 0°C, below -5°C, -10°C,
25 -15°C, -20°C, -25°C or -30°C.

- According to an embodiment of the invention is provided a use of a fuel comprising renewable hydrotreated fuel as a heating oil. This is advantageous in providing a fully renewable heating oil. Alternatively, such use makes it possible to use a blend of the renewable heating oil, which allows mixed use of the
30 renewable heating oil with e.g. fossil heating oil, or with a different renewable

heating oil. This is advantageous for the user, because there is no need to restrict the use to a single type of heating oil only.

EXAMPLES

The following examples are provided to illustrate various aspects of the present invention. They are not intended to limit the invention, which is defined by the accompanying claims.

Materials

The renewable hydrotreated fuel used as a heating oil in the examples is specified in Table 1.

- Carbon number profiles of the renewable hydrotreated heating oil and GTL were analysed by gas chromatography (GC). The results are shown in Fig. 1 and Fig. 2.

Table 1. Analysis of the used renewable hydrotreated heating oil.

Property	Method	Unit	Renewable hydrotreated heating oil
Density	ENISO12185:1996	kg/m ³	779.7
Cloud Point	ASTM D7689:2012	°C	-37
CFPP	EN116:2015	°C	-42
Viscosity 40 °C	ENISO3104:1996	mm ² /s	2.906
Flash point	ENISO2719:2002	°C	60.5

15

Several fuel compositions comprising varying amounts of a renewable hydrotreated heating oil and a naphthenic component were tested. The tested heating oil compositions are shown in Table 2, and detailed characteristics of two heating oil blends comprising renewable hydrotreated heating oil are shown in Table 3.

Table 2. Heating oil compositions.

Renewable hydrotreated heating oil, % by weight	Naphthenic component, % by weight	Density kg/m ³ (calculated)	Density kg/m ³ (measured)
0	100	817.1	817.1
90	10	783.4	783.9
95	5	781.6	782.1
100	0	779.7	779.7

20

Table 3. Detailed characteristic of heating oil compositions comprising 95% renewable hydrotreated heating oil and 5% heating oil containing aromatics or 5% fossil heating oil containing naphthenics.

Property	Method	unit	PA3 95% renewable heating oil + 5% heating oil containing naphthenics	PA7 95% renewable heating oil + 5% heating oil containing aromatics
Density	ENISO12185: 1996	kg/m ³	782.1	783.5
Cloud Point	ASTM D7689:2012	°C	-36.8	-32.6
Viscosity 40°C	ENISO3104: 1996	mm ² /s	2.89	2.95
Lower heating value	ASTM D4809: 2013	MJ/l	34.3	34.4
Oxidation stability	EN 16091: 2011	min	64.0	92.3
Naphtenics	ASTM D2425-04	wt%	3.03	1.56
Aromatics		wt%	0.33	1.79
Paraffins		wt%	96.6	96.7

Combustion

Test runs using a burner of domestic heating system were carried out for 100% renewable hydrotreated heating oil together with blends with fossil heating oil containing aromatics, fossil heating oil containing naphthenics and FAME. All blends could be used for extended periods of time in an equipment used for burning fossil heating oil. In the test the following heating system was used. Boiler: ARIMAX E 30 S, 30 kW; Burner: Oilon Solarheat LJ 10; Filter: Danfoss 2.37 kg/h.

Results from the combustion tests are shown in Table 4.

Table 4. Burning tests for heating oils. PA1 fossil heating oil containing aromatics; PA2 10% fossil heating oil containing aromatics + 90% renewable hydrotreated heating oil; PA4 10% fossil heating oil containing naphthenics + 90% renewable hydrotreated heating oil; PA6 10% FAME + 90% renewable hydrotreated heating oil; PA3 5% fossil heating oil containing naphthenics + 95% renewable hydrotreated heating oil; PA7 5% fossil heating oil containing aromatics + 95% renewable hydrotreated heating oil; PA8 renewable hydrotreated heating oil.

Heating oil composition	Fossil heating oil containing aromatics, wt%	Fossil heating oil containing naphthenics, wt%	FAME, wt%	Renewable hydrotreated heating oil, wt%	Burn time, α_{tot}	V, g/s	Total consumption, kg
PA1	100				17 h 3 min	0.565	34.68
PA2	10			90	14 h 23 min	0.593	30.70
PA3		5		95	14 h 27 min	0.589	30.64
PA4		10		90	14 h 29 min	0.591	30.82
PA6			10	90	7 h 35 min	0.593	16.19
PA7	5			95	7 h 40 min	0.592	16,34
PA8				100	10 h 27 min	0.592	22.27

Different non-binding aspects and embodiments of the present invention have been illustrated in the foregoing. The above embodiments are used merely to explain selected aspects or steps that may be utilized in implementations of the invention. Some embodiments may be presented only with reference to certain aspects of the invention. It should be appreciated that the corresponding embodiments may apply to other aspects as well. Any appropriate combinations of the embodiments may be formed.

Claims

1. A use of a fuel comprising renewable hydrotreated fuel as a heating oil.
2. The use according to claim 1 wherein the fuel comprises 40-100 wt-% renewable hydrotreated fuel.
- 5 3. The use according to claim 1 or 2, wherein the renewable hydrotreated fuel comprises at least 70 wt-%, more preferably more than 80 wt-%, most preferably more than 90 wt-% paraffinic components in the range of carbon number C₁₅-C₁₈.
- 10 4. The use according to any one claims 1-3, wherein the renewable hydrotreated fuel is obtained from at least one lignocellulosic source.
5. The use according to any one of claims 1-4 wherein the weight ratio of i-paraffins to n-paraffins in the renewable hydrotreated fuel is at least 2.3, 2.3, 3, or 4.
- 15 6. The use according to any one of claims 1-5, wherein the heating oil further comprises naphthenic hydrocarbons.
7. The use according to claim 6 wherein the amount of the naphthenic hydrocarbons is 1-5 % by weight, 1-10% by weight, or 1-50% by weight, preferably about 5% by weight.
- 20 8. The use according to any one of claims 1-7 wherein the renewable hydrotreated fuel comprises less than 10 wt-% aromatics.
9. The use according to any one of claims 1-8 comprising storage at a temperature below 0°C, below -10°C, or below -37°C.
10. The use according to any one of claims 1-9 comprising mixing the renewable hydrotreated fuel into a blend with a fossil fuel.
- 25 11. The use of claim 10 wherein 0-99%, 0-15% or 5-10% of fossil fuel is used in the blend with the renewable hydrotreated fuel.
12. The use according to any one of claims 1-11, wherein a colouring agent is included in the heating oil.
- 30 13. The use according to any one of claims 1-12, wherein the use comprises burning the heating oil in a heating system.

14. The use of claim 13 wherein the heating system is a domestic heating system for heating buildings, houses, or garages, or an industrial heating system for heating workshops, industrial facilities, premises or workspaces.
- 5 15. The use according to claim 13 or 14, wherein the heating system is a heating system for burning fossil fuel
16. The according to any one of claims 13-15 wherein the heating system comprises a burner for fossil fuel.
- 10 17. The use according to any one of claims 1-16, wherein the heating oil is provided in a container, which exposes the heating oil to low temperatures, preferably to a temperature below 5 °C.

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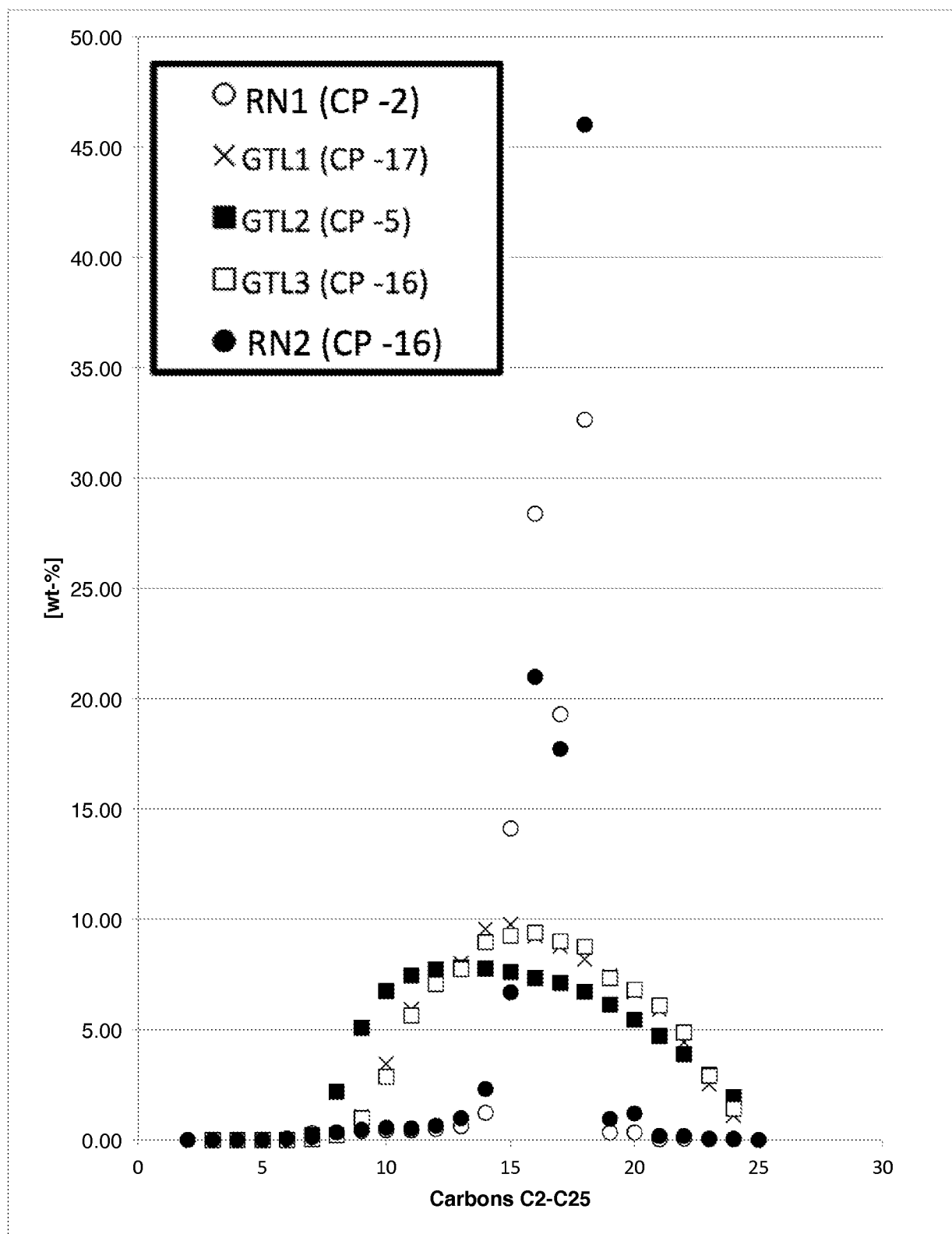


Fig. 1

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Carbon number	GTL1 Paraffins total [wt-%]	RN2 Paraffins total [wt-%]
3	0,00	0,00
4	0,00	0,00
5	0,00	0,01
6	0,00	0,05
7	0,03	0,11
8	0,20	0,32
9	1,08	0,46
10	3,46	0,56
11	5,93	0,52
12	7,20	0,64
13	8,03	0,97
14	9,55	2,29
15	9,76	6,68
16	9,23	20,98
17	8,78	17,71
18	8,18	46,03
19	7,42	0,94
20	6,72	1,20
21	5,93	0,17
22	4,43	0,19
23	2,54	0,04
24	1,11	0,02

Fig. 2

INTERNATIONAL SEARCH REPORT

International application No
PCT/FI2018/050602

A. CLASSIFICATION OF SUBJECT MATTER		
INV.	C10L1/02 F23K5/10	F23K5/02 F23K5/08 C10G3/00
C10L1/00		
ADD.		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
C10L F23K C10G		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
EPO-Internal, WPI Data		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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☒ Further documents are listed in the continuation of Box C. ☒ See patent family annex.		
* Special categories of cited documents : "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier application or patent but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
3 October 2018		06/11/2018
Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016		Authorized officer Bernet, Olivier

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