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MARINE FUEL COMPOSITIONS

Field of the Invention

The present invention relates to a marine fuel composition, and in particular to a marine fuel composition having a low sulphur content, and to
5 processes of making such compositions.

Background of the Invention

The current quality requirement of marine bunker oils in EU ECA (Emission Control Area) and North American ECA area require reduced sulphur emissions in marine
10 traffic. This can be achieved by installation of a flue gas cleaning system onboard or by use of bunker oil comprising a maximum of 0.5 or 0.1 wt% sulphur content.

The limit for sulphur maximum content in marine fuels has gradually decreased during 21st century from
15 4.5 wt% to 1 wt% and now to 0.1 wt%. Previously, when the sulphur limit was a maximum of 1 wt%, the bunker oils typically were obtained from heavy hydrocarbon fractions, such as from vacuum residue. Currently the low sulphur bunker oils are mainly blends of distillate gasoil type
20 fractions, which are lighter fractions than vacuum residue, also referred to as light bunker or distillate fuel oil.

Some approaches have been described to achieve low sulphur content in bunker oil, for example produced by
25 blending. WO2015/122931 discloses marine fuels with low sulphur content comprising at least about 10 and up to 50 wt% of a residual hydrocarbon component. It further comprises a non-hydroprocessed hydrocarbon component with which properties of the blend are adjusted to form a

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marine fuel composition that meets requirements for the desired application.

WO2019/005009 and WO2017/117161 relate to fuels and/or fuel blending components which can be formed from hydroprocessing of high lift deasphalted oil. However, these documents do not teach splitting the DAO Hydrowax into light and heavy fractions and they teach that the sulphur concentrates in the heavy bottom fraction.

EP0697455A2 relates to a process for producing a hydrowax, the focus being on a light hydrowax as an ethylene cracker feed or feed for lubricating base oils. Detailed properties are provided for this light fraction including a S content of 0.02 wt%. In this patent publication the heavy DAO hydrowax is described as a bottom fraction which contains many heavy hydrocarbonaceous compounds, partly polyaromatic ring structures. The only suggested use for this bottom fraction in this patent publication is to recycle it to the hydrocracker feed. No detailed properties are provided for this bottom fraction.

US2023/0059182 discloses a process for producing a low sulphur fuel oil bunker component from a vacuum residue, the low sulphur fuel oil bunker component having: density at 15°C between 0.985 and 0.999 g/cm³; viscosity at 135°C between 30-42 mm²/s; acid number of less than 1 mg/KOH/g; sulphur content of 4500-6000 wt ppm; and a nitrogen content of from 4000 to 5000 wt ppm, the process comprising: (a) providing a vacuum residue, and dividing said vacuum residue into a bypass stream and a feed to solvent deasphalting unit (SDA); (b) solvent deasphalting said feed to SDA and recovery of a deasphalted fraction; (c) hydrocracking a combined feed of said deasphalted fraction and the bypass stream at a

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hydrocracking unit having at least one ebullated bed reactor with constant catalyst activity; and (d) recovering the low sulphur fuel oil bunker component as a residue from said hydrocracking unit.

5 In view of the importance of providing marine fuel compositions having increasingly lower levels of sulphur in order to meet prevailing specifications, it would be desirable to provide alternative ways of producing marine fuel compositions wherein the sulphur level is less than
10 0.1 wt% (corresponding to 1000 wt ppm).

Summary of the Invention

 According to the present invention there is provided a low sulphur marine fuel composition comprising a heavy DAO hydrowax, wherein the heavy DAO hydrowax is
15 produced from a process comprising the steps of:
 (i) hydrocracking a deasphalted oil (DAO) and optionally up to 50% wt of flashed distillate by weight of the fuel composition;
 (ii) separating from the hydrocracker effluent a fraction
20 of which at least 80% by weight has a boiling point of 370°C or higher (the 370+ fraction); and
 (iii) separating the 370+ fraction into a top-fraction and a bottom-fraction at an effective cutpoint below 670°C, thus yielding the heavy DAO hydrowax as the bottom
25 fraction,
 wherein the heavy DAO hydrowax has a sulphur content of less than 1000 ppmw.

 According to another aspect of the present invention there is provided a process for producing a low sulphur
30 marine fuel composition comprising blending one or more marine fuel blending components with a heavy DAO hydrowax, wherein the heavy DAO hydrowax is produced from a process comprising the steps of:

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(i) hydrocracking a deasphalted oil (DAO) and optionally up to 50% wt of flashed distillate, by weight of the fuel composition;

5 (ii) separating from the hydrocracker effluent a fraction of which at least 80% by weight has a boiling point of 370°C or higher (the 370+ fraction); and

(iii) separating the 370+ fraction into a top-fraction and a bottom-fraction at an effective cutpoint below 670°C, thus yielding the heavy DAO hydrowax as the bottom
10 fraction.

It has surprisingly been found that the heavy DAO hydrowax produced herein has very low sulphur content (less than, and preferably significantly less than, 1000ppmw by weight of the heavy DAO hydrowax) and
15 therefore is a suitable blending component for formulating an ultra low sulphur marine fuel composition meeting the prevailing marine fuel specifications (the ECA requires <0.1wt% sulphur in the final marine fuel composition).

20 Detailed Description of the Invention

Production of DAO Hydrowax

An essential component of the marine fuel composition of the present invention is a heavy DAO Hydrowax. The heavy DAO hydrowax is produced from a process comprising
25 the steps of: (i) hydrocracking a deasphalted oil (DAO) and optionally up to 50% wt of flashed distillate; (ii) separating from the hydrocracker effluent a fraction of which at least 80% by weight has a boiling point of 370°C or higher (the 370+ fraction); and
30 (iii) separating the 370+ fraction into a top-fraction and a bottom-fraction at an effective cutpoint below 670°C, thus yielding the heavy DAO hydrowax as the bottom fraction.

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Because of the negative impact heavy metals usually have on the activity of hydrocracking catalysts, the blend of DAO and distillate fraction(s) should have a sufficiently low heavy metal content. It is therefore preferred that the heavy metal content of the hydrocracker feedstock has been reduced prior to hydrocracking. This implies that either the DAO is hydrodemetallised before being blended with the distillate fraction(s) or the blend of DAO and distillate fraction(s) is hydrodemetallised prior to being subjected to hydrocracking. In order to realize a high yield of DAO hydrowax it is economically efficient to aim for a high depth of deasphalting such that the DAO yield on residue feed exceeds 50 % wt. Generally such a high extraction depth is accompanied by a significant level of metals like V and Ni remaining in the DAO. Hence the hydrocracking of the DAO will generally start with hydrodemetallisation followed by hydrotreating and hydrocracking.

It has now been found that by flashing the 370+ fraction obtained from hydrodemetallization and subsequent hydrocracking of DAO with optionally up to 50 %wt flashed distillate at an effective cutpoint below 670°C, the heavy hydrowax obtained as the bottom-fraction has a very low sulphur content and can therefore very suitably be used as a blending component in a marine fuel composition.

Hydrocracking of the DAO with optionally up to 50 %wt flashed distillate may be performed in any suitable way known in the art. Generally, hydrocracking is carried out in the presence of hydrogen and a suitable hydrocracking catalyst at elevated temperature and pressure. Hydrocracking catalysts usually consist of one

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or more metals from nickel, tungsten, cobalt and molybdenum in elemental, oxidic or sulphidic form on a suitable carrier such as alumina, silica, silica-alumina or a zeolite. There are many commercially available hydrocracking catalysts, which can be suitably applied in the process according to the present invention. For the purpose of the present invention the hydrocracking process can be a single- or a multiple-staged process. In the case of a single-staged process, a stacked bed of a hydrodenitrification/first-stage hydrocracking catalyst on top of a conversion catalyst can suitably be used. Particularly suitable hydrodenitrification/first-stage hydrocracking catalysts are NiMo/alumina and CoMo/alumina, optionally promoted with phosphorus and/or fluorine. Suitable conversion catalysts include those based on a Group VIB metal, a Group VIII metal and an acidic carrier. A promoter in the form of phosphorus (P) may be present as well. Concrete examples of such catalysts are NiW/zeolite, NiW/silica-alumina and NiW/zeolite/-silica-alumina. Common hydrocracking conditions are an operating pressure of 80-250 bar, suitably 100-200 bar, and an operating temperature of 300-500 °C, suitably 350-475 °C.

The distillate fractions useful in the process of the present invention may be either heavy gas oil fractions obtained from the atmospheric distillation of a crude oil or a renewable feedstock, or flashed distillate fractions obtained from the vacuum flash distillation or vacuum distillation of an atmospheric hydrocarbon oil residue from crude oil or a renewable feedstock. For the purpose of the present invention it is not strictly required to use sharply defined distillate fractions (such as obtained in vacuum distillation) and therefore

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it is preferred that the distillate fractions are produced by the less expensive vacuum flash distillation of an atmospheric hydrocarbon oil residue.

5 The DAO used is suitably obtained by deasphalting a residual hydrocarbon oil, preferably a vacuum residue. The deasphalting may be carried out in any conventional manner. A well-known and suitable deasphalting method is solvent deasphalting, which involves the countercurrent treatment of the residual hydrocarbon oil feed with an
10 extracting solvent. This extracting solvent usually is a light hydrocarbon solvent containing paraffinic compounds having 3 to 8 carbon atoms, such as propane, butane, isobutane, pentane, isopentane, hexane and mixtures of two or more of these. Preferred paraffinic hydrocarbons
15 are those having 3 to 5 carbon atoms with butane, pentane and mixtures thereof being most preferred. The solvent deasphalting treatment is conveniently carried out in a rotating disc contactor or a plate column with the residual hydrocarbon oil feed entering at the top and the
20 extracting solvent entering at the bottom. The lighter hydrocarbons present in the residual hydrocarbon oil dissolve in the extracting solvent and are withdrawn at the top of the apparatus. From this top-fraction, the DAO is obtained after recovery of the extracting solvent. The
25 asphaltenes, which are insoluble in the extracting solvent, are withdrawn at the bottom of the apparatus. The conditions under which deasphalting takes place are known in the art. Suitably, deasphalting is carried out at a total extracting solvent to residual hydrocarbon oil
30 ratio of 1.5 to 8 wt/wt, a pressure of 1 to 60 bar and a temperature of 40 to 200 °C.

Hydrodemetallisation of either the DAO or the blend thereof with distillate fraction(s) can be achieved by

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any hydrodemetallisation method known in the art. Usually, such method involves passing the feed to be treated in an upward, downward or radial direction through one or more vertically disposed reactors

5 containing a fixed or moving bed of hydrodemetallisation catalyst particles at an elevated temperature and pressure in the presence of hydrogen. Well known hydrodemetallisation operations are the bunker flow operation, the fixed bed operation, the fixed bed swing

10 operation and the movable bed operation. Suitable catalysts usually consist of oxidic carriers such as alumina, silica or silica-alumina, on which one or more metals of Group VIB or VIII of the Periodic Table of Elements may be deposited either in elemental form or as

15 a metal compound. Such hydrodemetallisation catalysts are commercially available from many catalyst suppliers. Particularly suitable catalysts are those having as the active agent one of the combinations NiMo or CoMo, optionally promoted with phosphorus (P), on an alumina

20 carrier. It is well known that the type of catalysts described hereinbefore in practice will also exhibit some upgrading activity in terms of hydrodenitritification and/or hydrodesulphurization, removal of heavy hydrocarbons and conversion of hydrocarbons having a

25 boiling point above 520 °C into components having a lower boiling point. Hydrodemetallisation is usually carried out at a hydrogen partial pressure of 20-250 bar, a temperature of 300-470 °C, preferably 310-440 °C, and a space velocity of 0.1-10 l/l.hr, preferably 0.2-7 l/l.hr.

30 For the purpose of the present invention, it is preferred that the DAO used is produced by deasphalting a vacuum hydrocarbon oil residue, followed by hydrodemetallisation. Generally, a vacuum hydrocarbon oil

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residue is obtained as the residual fraction of the vacuum distillation of an atmospheric hydrocarbon oil residue. As already described above, the distillate fraction(s) used in the process according to the present invention are preferably obtained from the vacuum distillation of an atmospheric hydrocarbon oil residue as well. In a further preferred embodiment of the present invention said vacuum hydrocarbon oil residue from which the DAO is produced, is derived from the same atmospheric hydrocarbon oil residue as said distillate fraction(s).

Separation of the 370+ fraction from the hydrocracker effluent (step (ii)) can be achieved by means of fractionation devices commonly applied in hydrocracker units. The separation in step (iii) can also be performed by any method known in the art for separating a hydrocarbon oil feed into two or more different fractions based on the boiling points of the various components present in said hydrocarbon oil feed. Examples of suitable separation methods include distillation at atmospheric or reduced pressure, such as conducted in a mild vacuum flasher or a high vacuum distillation unit. The only important parameter in this respect for the purpose of the present invention is the effective cutpoint, i.e. the temperature indicating the boiling point of the highest boiling components of the top-fraction and the lowest boiling components of the bottom-fraction. In practice this will mean that at least 85% by weight, preferably at least 90% by weight and most preferably at least 95% by weight, of the components constituting the top-fraction has a boiling point below the effective cutpoint, while at least 70% by weight of the components constituting the bottom-fraction has a boiling point above the effective cutpoint. As already

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indicated above the effective cutpoint must be below 670 °C and preferably below 630 °C. Preferably, the effective cutpoint is above 490 °C and more preferably above 510 °C.

5 The heavy DAO hydrowax is eventually obtained in step (iii) as the bottom-fraction has very low sulphur content and therefore can be used directly as a blending component in a marine fuel composition. The heavy DAO hydrowax produced herein has a sulphur content of less
10 than 1000ppmw, preferably in the range from 20 ppmw to 150 ppmw.

 Preferably, the heavy DAO hydrowax produced herein has a CCAI of less than 800, more preferably below 780. CCAI stands for 'Calculated Carbon Aromaticity Index'
15 which is an index of the ignition quality of residual fuel oil. It is calculated according to the following equation:

$$CCAI = D - 140.7 \log(\log(V + 0.85)) - 80.6 - 483.5 \log\left(\frac{t + 273}{323}\right)$$

20

where:

D = density at 15°C (kg/m³)

V = viscosity (cSt)

t = viscosity temperature (°C)

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 Preferably, the heavy DAO hydrowax produced herein contains less than 20 wt% of 575°C minus material.

 Preferably, the heavy DAO hydrowax produced herein has a density at 70°C in the range from 840 kg/m³ to 880
30 kg/m³, more preferably from 845 kg/m³ to 870 kg/m³.

 Preferably, the heavy DAO hydrowax produced herein has a density at 15°C from 880 to 920 kg/m³, more

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preferably from 881 to 919 kg/m³, even more preferably from 885 to 910 kg/m³.

Preferably, the heavy DAO hydrowax produced herein has a kinematic viscosity at 100°C in the range from 20 to 100 cSt, more preferably from 30 to 65 cSt.

Preferably, the heavy DAO hydrowax produced herein has a T90 distillation point of greater than 700°C (i.e. at least 10 wt% of the material boils above 700°C).

Marine Fuel Compositions

The marine fuel compositions of the present invention preferably comprise from 0.1 wt% to 50 wt%, more preferably 1 to 30 wt%, even more preferably from 10 wt% to 25 wt%, of the heavy DAO hydrowax, by weight of the total marine fuel composition.

The marine fuel compositions of the present invention can further comprise any other marine fuel blending components known to those skilled in the art. Examples of suitable marine fuel blending components includes residual hydrocarbon components, non-hydroprocessed hydrocarbon components and hydroprocessed hydrocarbon components. Examples of residual hydrocarbon components include long residues (Atmospheric Tower Bottoms), short residues (Vacuum Tower Bottoms), and a combination thereof. Examples of non-hydroprocessed hydrocarbon component is selected from the group consisting of light cycle oil (LCO), heavy cycle oil (HCO), fluid catalytic cracking (FCC) cycle oil, FCC slurry oil, pyrolysis gas oil, cracked light gas oil (CLGO), cracked heavy gas oil (CHGO), pyrolysis light gas oil (PLGO), pyrolysis heavy gas oil (PHGO), thermally cracked residue, thermally cracked heavy distillate, coker heavy distillates, and any combination thereof. In some embodiments, the non-hydroprocessed hydrocarbon

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component is selected from a group consisting of vacuum gas oil (VGO), coker diesel, coker gas oil, coker VGO, thermally cracked VGO, thermally cracked diesel, thermally cracked gas oil, Group I slack waxes, lube oil aromatic extracts, deasphalted oil (DAO), and any combination thereof. In yet another embodiment, in addition to or alternatively, the non-hydroprocessed hydrocarbon component is selected from the group consisting of coker kerosene, thermally cracked kerosene, gas-to-liquids (GTL) wax, GTL hydrocarbons, straight-run diesel, straight-run kerosene, straight run gas oil (SRGO), and any combination thereof.

Examples of hydroprocessed hydrocarbon components are selected from a group consisting of low-sulphur diesel (LSD) of less than about 500 wppm of sulphur, particularly ultra low-sulphur diesel (ULSD) of less than 15 or 10 wppm of sulphur; hydrotreated LCO; hydrotreated HCO; hydrotreated FCC cycle oil; hydrotreated pyrolysis gas oil, hydrotreated PLGO, hydrotreated PHGO, hydrotreated CLGO, hydrotreated CHGO, hydrotreated coker heavy distillates, hydrotreated thermally cracked heavy distillate, and any combination thereof. In another embodiment, in addition to or alternatively, the hydroprocessed hydrocarbon component is selected from a group consisting of hydrotreated coker diesel, hydrotreated coker gas oil, hydrotreated thermally cracked diesel, hydrotreated thermally cracked gas oil, hydrotreated VGO, hydrotreated coker VGO, hydrotreated residues, hydrocracker bottoms (which can also be known as hydrocracker hydrowax), hydrotreated thermally cracked VGO, and hydrotreated hydrocracker DAO, and any combination thereof. In yet another embodiment, in addition to or alternatively, the hydroprocessed

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hydrocarbon component is selected from a group consisting of ultra low sulphur kerosene (ULSK), hydrotreated jet fuel, hydrotreated kerosene, hydrotreated coker kerosene, hydrocracker diesel, hydrocracker kerosene, hydrotreated thermally cracked kerosene, and any combination thereof. While preferred, a hydroprocessed hydrocarbon component is not required in a marine fuel composition described herein, particularly when a residual hydrocarbon component and a non-hydroprocessed hydrocarbon component can provide the marine fuel composition with the requisite or desired properties.

Further details of suitable marine fuel blending components can be found in WO2015/112931 incorporated herein by reference in its entirety.

Examples of such other components for use in the marine fuel compositions herein can include, but are not limited to, detergents, viscosity modifiers, pour point depressants, lubricity modifiers, dehazers, e.g. alkoxyated phenol formaldehyde polymers; anti-foaming agents (e.g., polyether-modified polysiloxanes); ignition improvers (cetane improvers) (e.g. 2-ethylhexyl nitrate (EHN), cyclohexyl nitrate, di-tert-butyl peroxide and those disclosed in U.S. Pat. No. 4,208,190 at column 2, line 27 to column 3, line 21); anti-rust agents (e.g. a propane-1,2-diol semi-ester of tetrapropenyl succinic acid, or polyhydric alcohol esters of a succinic acid derivative, the succinic acid derivative having on at least one of its alpha-carbon atoms an unsubstituted or substituted aliphatic hydrocarbon group containing from 20 to 500 carbon atoms, e.g. the pentaerythritol diester of polyisobutylene-substituted succinic acid); corrosion inhibitors; deodorants; anti-wear additives; anti-oxidants (e.g. phenolics such as 2,6-di-tert-butylphenol,

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or phenylenediamines such as N,N'-di-sec-butyl-p-phenylenediamine); metal deactivators; static dissipator additives; combustion improvers; and mixtures thereof.

5 If desired, one or more additive components, such as those listed above, may be co-mixed preferably together with suitable diluent(s) in an additive concentrate, and the additive concentrate may then be dispersed into the base fuel, or into the base fuel/wax blend, in order to prepare a fuel composition according to the present
10 invention.

In one embodiment, the marine fuel composition has a maximum sulphur content of 1000 wppm (parts per million by weight) or 0.1wt%. In some embodiments, the marine fuel composition can exhibit a sulphur content in a range
15 of about 850 wppm to 1000 wppm, for example about 900 wppm, 950 wppm, or 1000 wppm. In other embodiments, the marine fuel composition can exhibit a sulphur content of at most 1000 wppm, for example at most 1000 wppm, at most 950 wppm, at most 900 wppm, at most 850 wppm, at most 800
20 wppm, at most 750 wppm, at most 700 wppm, at most 650 wppm, at most 600 wppm, at most 550 wppm, at most 500 wppm, at most 450 wppm, at most 400 wppm, at most 350 wppm, at most 300 wppm, or at most 250 wppm. In some embodiments, the marine fuel composition can exhibit a
25 sulphur content of at least 250 wppm, at least 300 wppm, at least 350 wppm, at least 400 wppm, at least 450 wppm, at least 500 wppm, at least 550 wppm, at least 600 wppm, at least 650 wppm, at least 700 wppm, at least 750 wppm, at least 800 wppm, at least 850 wppm, or at least 900
30 wppm, at least 950 wppm, at least 1000 wppm.

In a preferred embodiment herein, the marine fuel composition of the present invention has a density at 15°C of greater than 0.90 g/cm³. Hence, the marine fuel

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composition of the present invention can be described as a marine fuel oil, rather than a marine gasoil.

The present invention will be further understood from the following examples. Unless otherwise stated, all amounts and concentrations disclosed in the examples are based on weight of the fully formulated fuel composition.

Examples

A DAO hydrowax stream from the Solvent de-Asphalting unit, SDA, and hydrocracking unit was evaluated to check its suitability as a marine fuel blending component. The feed to the hydrocracking unit used for the preparation of this DAO hydrowax had a sulphur content of 2.4 wt% and a nitrogen content of 0.25 wt%. The main goal of this study was to characterize the physical and chemical properties of the heavy fraction, Fr:>600°C.

Approximately 10L of DAO hydrowax was distilled. Distillation was performed according to ASTM D5236. Three distillations were performed from the DAO hydrowax feed in order to obtain the following cuts for this study:

1st Distillation with one cut point:

Fr:>430°C: Residue 1

2nd Distillation with four cut points:

Fr:370-430°C:

Fr: 430-475°C:

Fr: 475-520°C:

Fr: >520°C: Residue 2

3rd Distillation with two cut points:

Fr: 520-600°C

Fr: >600°C: Residue 3

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Physical and chemical characterization was conducted on all samples.

5 The distillation yields for the Waxy Distillates/Residues are summarized in Table 1 below:

Table 1

Fractions/Distillation Cuts (ATSM D5236) :	Yield %m/m
DAO Wax Neat	-
Fr:<430°C	15.0
Fr:>430°C	85.0
Fr:<370°C	2.7
Fr: 360-430°C	11.8
Fr: 430-475°C	10.9
Fr:475-520°C	8.2
Fr:>520°C	66.3
Fr:<520°C	36.9
Fr:520-600°C	24.9
Fr:>600°C	38.2

10 Various physical and chemical properties of the various fractions were measured using standard test methods and the results are set out below in Tables 2 to 9. Table 2 sets out the viscosity at 100°C for the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 3 sets out the density at 70°C for the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 4 sets out the density at 15°C for the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 5 sets out the sulphur content of the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 6 sets out the pour point for the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 7 sets out the total nitrogen content of the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and

Fr:>600°C fractions. Table 8 sets out the total metal content of the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 9 sets out the CCAI of the DAO hydrowax (neat), Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 10 sets out the >700°C content of the Fr:>430°C, Fr:>520°C and Fr:>600°C fractions. Table 11 sets out the CCR data of the Fr:>430°C, Fr:>520°C and Fr:>600°C fractions (according to ASTM D189).

The CCAI is calculated according to the equation below:

$$CCAI = D - 140.7 \log(\log(V + 0.85)) - 80.6 - 483.5 \log\left(\frac{t + 273}{323}\right)$$

where:

D = density at 15°C (kg/m³)

V = viscosity (cSt)

t = viscosity temperature (°C)

Table 2

Fraction:	Kinematic Viscosity at 100°C (cSt) (ATSM D445)
DAO Hydrowax (Neat)	16.02
Fr:>430°C	23.40
Fr:>520°C	34.21
Fr:>600°C	53.54

Table 3

Fraction:	Density at 70°C (g/ml) (ASTM D4052)
DAO Hydrowax (Neat)	0.8462
Fr:>430°C	0.8533
Fr:>520°C	0.8559
Fr:>600°C	0.8603

Table 4

Fraction:	Density at 15°C (kg/m³) (calculated from d70)
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DAO Hydrowax (Neat)	885
Fr:>430°C	892
Fr:>520°C	897.3
Fr:>600°C	899

Table 5

Fraction:	Total Sulphur content (mg/kg) (ASTM D2622)
DAO Hydrowax (Neat)	52
Fr:>430°C	60
Fr:>520°C	67
Fr:>600°C	70

Table 6

Fraction:	Pour Point (°C) (ASTM D5985)
DAO Hydrowax (Neat)	33
Fr:>430°C	33
Fr:>520°C	33
Fr:>600°C	30

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Table 7

Fraction:	Total Nitrogen content (mg/kg) (ASTM D5762)
DAO Hydrowax (Neat)	35
Fr:>430°C	38
Fr:>520°C	43
Fr:>600°C	45

Table 8

Fraction:	Total Metal Content (ppmw) (NEN6966)
DAO Hydrowax (Neat)	<2
Fr:>430°C	<2
Fr:>520°C	<2
Fr:>600°C	<2

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Table 9

Fraction:	CCAI (calculated)
DAO Hydrowax (Neat)	762
Fr:>430°C	761
Fr:>520°C	760
Fr:>600°C	754

Table 10

Fraction:	700°C plus content (%wt)
Fr:>430°C	Not Measured
Fr:>520°C	20
Fr:>600°C	26

Table 11

Fraction:	CCR (%wt) (ASTM D189)
Fr:>430°C	0.6
Fr:>520°C	0.9
Fr:>600°C	1.1

5 Discussion

 It can be seen from Table 5 that the Fr:>600°C fraction contains 70 ppmw of sulphur. This is a very low level of sulphur and is significantly below the 1000 ppmw maximum level required by the ECA for marine fuels. In addition, the Fr:>600°C has a favourable CCAI value of 754 (the ECA spec is 860 max.). Therefore, the Fr:>600°C fraction is suitable as a marine fuel blending component. As the sulphur level of the Fr:>600°C is significantly below the 1000 ppmw maximum level required by ECA for marine fuels, it can be blended with other marine blending components which may have a higher sulphur level to provide a final marine fuel composition still having very low sulphur levels.

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C L A I M S

1. A low sulphur marine fuel composition comprising a heavy DAO hydrowax, wherein the heavy DAO hydrowax is produced from a process comprising the steps of:
- 5 (i) hydrocracking a deasphalted oil (DAO) and optionally up to 50% wt of flashed distillate, by weight of the fuel composition;
- (ii) separating from the hydrocracker effluent a fraction of which at least 80% by weight has a boiling point of 370°C or higher (the 370+ fraction);
- 10 and
- (iii) separating the 370+ fraction into a top-fraction and a bottom-fraction at an effective cutpoint below 670°C, thus yielding the heavy DAO hydrowax as the bottom fraction,
- 15 wherein the heavy DAO hydrowax has a sulphur content of less than 1000 ppmw.
2. A low sulphur marine fuel composition according to Claim 1 wherein the heavy DAO hydrowax has a sulphur
- 20 content in the range from 20 ppmw to 150 ppmw.
3. A low sulphur marine fuel composition according to Claim 1 or 2 wherein the heavy DAO hydrowax has a CCAI of less than 800.
- 25 4. A low sulphur marine fuel composition according any of Claims 1 to 3, wherein the heavy DAO hydrowax has a CCAI of less than 780.

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5. A low sulphur marine fuel composition according to any of Claims 1 to 4 wherein the heavy DAO hydrowax contains less than 20 wt% of 575°C minus material.
- 5 6. A low sulphur marine fuel composition according to any of Claims 1 to 5 wherein the heavy DAO hydrowax has a density at 70°C in the range from 840 kg/m³ to 880 kg/m³.
- 10 7. A low sulphur marine fuel composition according to any of Claims 1 to 6 wherein the heavy DAO hydrowax has a density at 15°C in the range from 881 kg/m³ to 919 kg/m³.
- 15 8. A low sulphur marine fuel composition according to any of Claims 1 to 7 wherein the heavy DAO hydrowax has a kinematic viscosity at 100°C in the range from 20 to 100 cSt.
- 20 9. A low sulphur marine fuel composition according to any of Claims 1 to 7 which comprises from 0.1 wt% to 50 wt% of the heavy DAO hydrowax.
- 25 10. A low sulphur marine fuel composition according to any of Claims 1 to 9 wherein the low sulphur marine fuel composition comprises additional marine blending components.
- 30 11. A process for producing a low sulphur marine fuel composition comprising blending one or more marine fuel blending components with a heavy DAO hydrowax, wherein the heavy DAO hydrowax is produced from a process comprising the steps of:

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- (i) hydrocracking a deasphalted oil (DAO) and optionally up to 50% wt of flashed distillate, by weight of the fuel composition;
- 5 (ii) separating from the hydrocracker effluent a fraction of which at least 80% by weight has a boiling point of 370°C or higher (the 370+ fraction); and
- 10 (iii) separating the 370+ fraction into a top-fraction and a bottom-fraction at an effective cutpoint below 670°C, thus yielding the heavy DAO hydrowax as the bottom fraction.