(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) EP 4 183 855 A1

(12) # EUROPEAN PATENT APPLICATION

(43) Date of publication:
24.05.2023 Bulletin 2023/21

(21) Application number: **21208970.0**

(22) Date of filing: **18.11.2021**

(51) International Patent Classification (IPC):
C10L 1/02 *(2006.01)*

(52) Cooperative Patent Classification (CPC):
C10L 1/02

(84) Designated Contracting States:
AL AT BE BG CH CY CZ DE DK EE ES FI FR GB GR HR HU IE IS IT LI LT LU LV MC MK MT NL NO PL PT RO RS SE SI SK SM TR
Designated Extension States:
BA ME
Designated Validation States:
KH MA MD TN

(71) Applicant: **Neste Oyj**
02150 Espoo (FI)

(72) Inventors:
- **HAARA, Riikka-Mari**
06101 Porvoo (FI)
- **KOUVA, Merja**
06101 Porvoo (FI)
- **KARVINEN, Esko**
06101 Porvoo (FI)
- **KIISKI, Ulla**
06101 Porvoo (FI)
- **RÄMÖ, Virpi**
06101 Porvoo (FI)
- **RÄSÄNEN, Jukka**
06101 Porvoo (FI)
- **RAUTELIN, Wolter**
06101 Porvoo (FI)

(74) Representative: **Laine IP Oy**
Porkkalankatu 24
00180 Helsinki (FI)

(54) **A MARINE FUEL BLEND**

(57) The present invention relates to a marine fuel blend having a kinematic viscosity of 1-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996 and comprising 0.5 - 50 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol.

EP 4 183 855 A1

Description

FIELD

[0001] The present invention relates to a marine fuel blend as well as use of a marine fuel blend and a method for manufacturing the marine fuel blend.

BACKGROUND AND OBJECTS

[0002] Marine fuels are traditionally based on fossil oil and are usually of higher viscosity than for example gasoline and diesel used for land vehicles. However, due to the problems related to pollution and climate change, there exists a need to also provide marine fuels having a lower sulphur content, for example. Another need is to reduce the emission of greenhouse gas (GHG) emissions. It is indeed an aim of the International Maritime Organisation IMO to reduce the total annual GHG emissions from international shipping by at least 50 % by 2050, compared to the level of 2008. This target may be achieved by improving for example efficiency of motors and operations, but also alternative fuels are needed.

[0003] Natural or raw cashew nut shell liquid (natural CNSL) is a by-product of the cashew industry, directly extracted from the shell of the cashew nut, fruit of the cashew tree, Anacardium occidentale. The oil is extracted from the cashew nut shell, which is a pericarp fluid of the cashew nut shell. Natural CNSL is a mixture of four components, all of which are substituted phenols: anacardic acid, cardanol, cardol and 2-methyl cardol. Physically extracted natural CNSL contains about 70 wt-% of anacardic acids, about 18 wt-% of cardol and about 5 wt-% of cardanol. The physically extracted natural CNSL may be processed such that the anacardic acid is decarboxylated into cardanol, leading to so-called technical CNSL. The technical CNSL may be further purified by distillation.

[0004] Asphaltenes are large aromatic molecules that are suspended colloids in crude oil and heavy fuel oil. Asphaltenes stay dispersed in the oil when they are surrounded by resins (polar aromatics) and the oil is then said to be stable. Under unfavourable solvent conditions resins are desorbed from asphaltenes causing asphaltenes to flocculate. This precipitation will increase the sediment amount in the oil. Large sediment amounts cause problems when operating vessels, especially in filters and separators. When asphaltene containing fuel is stored for a long period of time and/or heated, its stability begins to deteriorate and asphaltenes precipitate out from the fuel causing an increase of the sediment amount.

[0005] It is an aim to provide a use for cashew nut shell liquid (CNSL). Another aim is to provide an alternative marine fuel and marine fuel blend. A still further aim is to provide a marine fuel blend that has less fossil-based components than traditional marine fuels, i.e., to provide a marine fuel blend having a renewable component therein. A still further aim is to provide a marine fuel blend where the asphaltenes are stabilised and do not form sediments. A still further aim is to provide a marine fuel blend, which allows reduction of greenhouse gas emissions.

SUMMARY OF THE INVENTION

[0006] The invention is defined by the features of the independent claim. Some specific embodiments are defined in the dependent claims. According to an aspect, there is provided a marine fuel blend having a kinematic viscosity of 1-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996, and comprising 0.5 - 50 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol.

[0007] According to another aspect, there is provided a use of refined cashew nut shell liquid comprising at least 50 wt-% of cardanol as asphaltene stabiliser for marine bunker fuels. Another use of refined cashew nut shell liquid comprising at least 50 wt-% of cardanol is as a marine fuel component.

[0008] According to yet another aspect, there is provided a method for manufacturing a marine fuel, comprising mixing a base component with 0.5 - 50 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol.

DETAILED DESCRIPTION

[0009] In the present description, weight percentages (wt-%) are calculated on the total weight of the blend. Volume percentages (vol-%) are also calculated on the total volume of the blend.

[0010] The term "renewable" in the context of a renewable fuel component refers to one or more organic compounds derived from any renewable source (i.e., not from any fossil-based source). Thus, the renewable fuel component is based on renewable sources and consequently does not originate from or is derived from any fossil-based material. Such component is characterised by mandatorily having a higher content of ^{14}C isotopes than similar components derived from fossil sources. Said higher content of ^{14}C isotopes is an inherent feature characterizing the renewable fuel component and distinguishing it from fossil fuels. Thus, in fuel blends, wherein a portion of the blends is based on partly fossil based material and partly renewable fuel component, the renewable component can be determined by measuring the ^{14}C activity. Analysis of ^{14}C (also referred to as carbon dating or radiocarbon analysis) is an established approach to determine the age of artefacts based on the rate of decay of the isotope ^{14}C, as compared to ^{12}C. This method may be used to determine the physical percentage fraction of renewable materials in bio/fossil mixtures as renewable material is far less aged than fossil material and so the types of material contain very different ratios of ^{14}C:^{12}C. Thus, a particular ratio of said isotopes can be used as a "tag" to identify a renewable carbon compound and differentiate it from non-renewable carbon compounds. While the renewable component reflects the modern atmospheric ^{14}C activity, very little ^{14}C is present in fossil fuels (oil, coal). Therefore, the renewable fraction of any material of interest is proportional to its ^{14}C content. Samples of fuel blends may be analysed post-reaction to determine the amount of renewable sourced carbon in the fuel. This approach would work equally for co-processed fuels or fuels produced from mixed feedstocks. It is to be noted that there is not necessarily any need to test input materials when using this approach as renewability of the fuel blend may be directly measured. The isotope ratio does not change during chemical reactions. Therefore, the isotope ratio can be used for identifying renewable isomeric paraffin compositions, renewable hydrocarbons, renewable monomers, renewable polymers, and materials and products derived from said polymers, and distinguishing them from non-renewable materials. Feedstock of raw material of biological origin means material having only renewable (i.e., contemporary or biobased or biogenic) carbon, ^{14}C, content which may be determined using radiocarbon analysis by the isotopic distribution involving ^{14}C, ^{13}C and/or ^{12}C as described in ASTM D6866 (2018). Other examples of a suitable method for analysing the content of carbon from biological or renewable sources are DIN 51637 (2014) or EN 16640 (2017).

[0011] For the purpose of the present invention, a carbon-containing material, such as a feedstock or product is considered to be of biological i.e., renewable origin if it contains 90 % or more modern carbon (pMC), such as 100 % modern carbon, as measured using ASTM D6866.

[0012] According to an aspect of the present invention, there is provided a marine fuel blend having a kinematic viscosity of 1-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996, and comprising 0.5 - 50 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol.

[0013] The marine fuel blend thus comprises a certain amount of refined cashew nut shell liquid, also called in this description refined CNSL or simply CNSL, while it may also be called refined cashew nut shell oil (CNSO). Indeed, in the present description of the invention, the abbreviation "CNSL" is to be understood as refined CNSL, not natural or raw CNSL. The marine fuel blend also fulfils at least one of the specifications of ISO 8217:2017(E) for marine fuels, the standard listing several different marine fuel specifications. The present marine fuel blend thus allows providing a decarbonised marine fuel blend to meet the stricter environmental requirements. It also provides a marine fuel blend that comprises components that are not usable for food industry. The renewable component used in the present marine fuel blend is scalable and economical.

[0014] The marine fuel blend comprises 0.5 - 50 vol-% of refined cashew nut shell liquid, the rest of the blend (i.e. up to 100 vol-%) being other suitable component(s). The blend may thus comprise from 0.5, 1, 1.5, 2, 3, 4, 5, 7, 10, 12, 15, 17, 20, 22, 25, 27, 30, 32, 35, 37, 40 or 42 vo -%, up to 2, 3, 4, 5, 7, 10, 12, 15, 17, 20, 22, 25, 27, 30, 32, 35, 37, 40, 42, 47 or 50 vol-% of refined CNSL. The amount of refined CNSL may be for example 0.5-30 vol-%, 0.5-20 vol-% or 0.5-10 vol-% of the total weight of the blend.

[0015] The cashew nut shell liquid comprises at least 50 wt-% of cardanol. According to an embodiment, it comprises at least 80 wt-% of cardanol, or at least 90 wt-% of cardanol. The CNSL may thus comprise at least 50, 55, 60, 65, 70, 75, 80, 85 or 90 wt-%, up to 60, 65, 70, 75, 80, 85, 90 or 95 wt-% of cardanol. The amount of cardanol in the CNSL may be for example 50-80 wt-% or 60-90 wt-%.

[0016] According to an embodiment, the cashew nut shell liquid has been refined by any of vacuum distillation, distillation, heat treatment, filtration, degumming or combinations thereof. For example, the CNSL may have been refined by vacuum distillation at 200 - 240 °C under a pressure of 2.5 - 3.5 mbar. It has been noticed that these distillation conditions lead to a high yield of cardanol in the refined CNSL. The natural or raw CNSL may also be purified with supercritical CO_2 extraction, distillation, heat treatment, filtration, degumming, combination or filtration and degumming or any other suitable way, such as a combination of two or more of the above.

[0017] The kinematic viscosity of the marine fuel blend is 1-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996. The kinematic viscosity may thus be for example from 1, 2, 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 100, 120, 140, 150, 170, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450,475, 500, 525, 550, 575, 600, 625, 650 or 675 mm^2/s, up to 5, 10, 15, 20, 25, 30, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 100, 120, 140, 150, 170, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450,475, 500, 525, 550, 575, 600, 625, 650, 675 or 700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996.

[0018] According to an embodiment, the kinematic viscosity of the marine fuel blend is 1-30 mm^2/s as measured at 50 °C according to EN ISO 3104:1996. The kinematic viscosity may thus be for example from 1, 2, 3, 4, 5, 7, 9, 10, 12, 14, 15, 17, 20, 22 or 25 mm^2/s up to 3, 4, 5, 7, 9, 10, 12, 14, 15, 17, 20, 22, 25, 27 or 30 mm^2/s as measured at 50 °C according to EN ISO 3104:1996.

[0019] Such marine fuel blends having a lower kinematic viscosity may comprise 0.5-20 vol-% of refined cashew nut shell liquid. The amount of refined CNSL in these blends may be 0.5, 1, 1.5, 2, 3, 4, 5, 7, 10, 12, 15 or 17 vol-%, up to 2, 3, 4, 5, 7, 10, 12, 15, 17 or 20 vol-%.

[0020] According to an embodiment, the marine fuel blend has a pour point of 5-30 °C as measured by EN ISO 3016:2019. According to a preferred embodiment, the pour point is 15-30 °C, or more preferably, 20-30 °C as measured by EN ISO 3016:2019. The pour point may thus be for example from 5, 10, 15 or 20 °C up to 10, 15, 20, 25 or 30 °C as measured by EN ISO 3016:2019.

[0021] Marine fuel blends typically comprise or form some amounts of sediments, when the fuel blend is heated and/or stored for a long period of time. For marine fuel blends in the category of RMB and RMG, these are measured according to ISO 10307-2A:2009, and are called Total sediment - Aged, or Potential Total Sediment, abbreviated TSP. In this description, the abbreviation TSP is used for RMB and RMG. For marine fuel blends in the category of DMB, the measurement method is described in ISO 10307-1:2009, and are called Total sediment by hot filtration, or Existent Total Sediment, abbreviated TSE. In this description, the abbreviation TSE is used for DMB.

[0022] According to another embodiment, the marine fuel blend has an amount of aged sediment, TSP, of less than 0.10 wt-%, as measured by ISO 10307-2A:2009 or TSE, as measured by ISO 10307-1:2009, is less than 0.10 wt-%. This amount fulfils the requirements of the standard for marine fuels. The amount of aged sediment may even be less than 0.08, 0.07, 0.06 or 0.05 wt-% or even lower.

[0023] The marine fuel blend may also have an ash content of less than 0.1 wt-%, as measured by ISO 6245:2002. This ash content fulfils the requirements of the standard for marine fuels.

[0024] The sulphur content of the marine fuel blend is preferably at most 0.1 wt-%, as measured by ISO 8754:2003. This sulphur content fulfils the requirements of the standard for Sulphur Emission Control Area (SECA area). The sulphur content may even be less than 0.09, 0.08, 0.07, 0.06, 0.05, 0.04 or 0.03, wt-%, or even lower.

[0025] The Pensky-Martens flash point of the marine fuel blend is over 60 °C, preferably 100-150 °C as measured by EN ISO 2719:2016.

[0026] Indeed, despite its different chemistry, it was observed (as will be shown below in the Experimental section), that refined CNSL was found to fulfil both RMB and RMG specification (ISO 8217:2017) when blended with conventional fossil based RMB or RMG. Based on simulated distillation, behaviour of the CNSL containing blends resemble well the conventional RMB/RMG distillation behaviour and thus no obvious combustion issues can be seen. As RMB's/RMG's comprising or consisting of non-fossil based components need to fulfil the same requirements as fossil based RMB/RMG, it is believed that CNSL would be combinable with those RMB's/RMG's as well, without any difficulties.

[0027] According to another embodiment, the kinematic viscosity of the marine fuel blend is 31-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996. The kinematic viscosity may thus be for example from 31, 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 100, 120, 130, 140, 150, 170, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450,475, 500, 525, 550, 575, 600, 625, 650 or 675 mm^2/s, up to 35, 40, 45, 50, 55, 60, 65, 70, 75, 80, 85, 90, 100, 120, 130, 140, 150, 170, 200, 225, 250, 275, 300, 325, 350, 375, 400, 425, 450,475, 500, 525, 550, 575, 600, 625, 650, 675 or 700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996. The kinematic viscosity is preferably 90-130 mm^2/s as measured at 50 °C according to EN ISO 3104:1996.

[0028] Such marine fuel blends having a higher kinematic viscosity may comprise 0.5-20 vol-% of refined cashew nut shell liquid. The amount of refined CNSL in these blends may be 0.5, 1, 1.5, 2, 3, 4, 5, 7, 10, 12, 15 or 17 vol-%, up to 2, 3, 4, 5, 7, 10, 12, 15, 17 or 20 vol-%. The amount of refined CNSL is preferably 0.5-10 vol-%.

[0029] The amount of aged sediment of a marine fuel blend comprising refined CNSL is typically 0.01-0.11 wt-% lower than that of the other component(s) of the blend (i.e. the blend without refined CNSL), when measured with the same measurement method. Typically, the use of refined CNSL allows lowering the amount of aged sediments by 0.05-0.10 wt-% compared to not using the refined CNSL.

[0030] The sulphur content of the marine fuel blend is preferably at most 0.5 wt-%, as measured by ISO 8754:2003. This sulphur content fulfils the requirements of the standard for marine fuels. The sulphur content may even be less than 0.45, 0.40, 0.35, 0.30, 0.25, 0.20, 0.15, 0.10 or 0.05 wt-%, or even lower.

[0031] Furthermore, these marine fuel blends are especially suitable for achieving the requirements of RMG grade with a maximum of 0.5 wt-% sulphur marine fuel specification. Indeed, these fuels comprise highly cracked asphaltenes of resid hydrocracker 560 °C + bottom oil, which need to be kept dispersed in the oil. It has now been observed (as will be shown in the Experimental section) that the stabilising cardanol component derived from cashew nut shell liquid keeps the asphaltenes in the solution and aged sediment limit in the bunker specification ISO 8217:2017 is fulfilled. Indeed, the laboratory test method for aged sediment (ISO 10307-2:2009) simulates ageing of a fuel and the marine fuel specification ISO 8217:2017 defines a limit for the aged sediment amount in marine fuels.

[0032] The fossil part of the marine fuel blend may comprise distillate marine fuel or fuels, residual marine fuel or fuels or mixtures thereof. For example, the marine fuel blend may comprise 10 vol-% of residual marine fuel, up to 50 vol-% of CNSL, the rest being distillate marine fuel.

[0033] The composition of the marine fuel blend may also be for example 90 vol-% of residual marine fuel and 10 vol-% of CNSL. Alternatively, the composition may be 80 vol-% of residual marine fuel and 20 vol-% of CNSL.

[0034] The present marine fuel blend may comprise any known marine fuel or mixtures thereof. For example, it may comprise marine fuels as defined by their properties in ISO 8217:2017(E), i.e. DMX, DMA, DFA, DMZ, DFZ, DMB, DFB, RMA, RMB, RMD, RME, RMG or RMK, such as RMG180, RMG380, RMG500 or RMG700 or RMK380, RMK500 or RMK700.

[0035] The present marine fuel blend may naturally also comprise other non-fossil components, such as renewable components. It is also possible that the blend does not comprise any fossil component at all.

[0036] According to an embodiment, there is thus provided a marine fuel blend having a viscosity of 1-30 mm^2/s as measured at 50 °C according to EN ISO 3104:1996, comprising 0.5 - 50 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol. According to another embodiment, there is provided a marine fuel blend having a viscosity of 31-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996, comprising 0.5 - 20 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol.

[0037] According to another aspect, there is provided a use of refined cashew nut shell liquid comprising at least 50 wt-% of cardanol as asphaltene stabiliser for marine bunker fuels. Another use of refined cashew nut shell liquid comprising at least 50 wt-% of cardanol is as a marine fuel component.

[0038] Indeed, as will be demonstrated below in the Experimental part, it has been observed that use of the present CNSL in a marine fuel allows to stabilise asphaltenes in marine bunker fuels, leading to better stability of the fuels and less clogging problems for filters etc.

[0039] According to another aspect, there is provided use of a marine fuel blend for reducing the greenhouse gas emissions at least 4 % as CO_{2eq}/MJ calculated according to the directive 2018/2001 of the European Parliament and of the Council, of 11 December 2018 on the promotion of the use of energy from renewable sources. Indeed, a reduction of 4 % of the GHG emissions is obtained when using 5 vol-% of CNSL, while a reduction of 9 % is achieved when using 10 vol-% of CNSL. The use of the present marine fuel blend indeed allows to reduce the GHG emissions, as it comprises renewable material. The present marine fuel blend thus fulfils at least partly the requirements of IMO, with respect to reductions of greenhouse gas emissions, as discussed above.

[0040] According to yet another aspect, there is provided a method for manufacturing a marine fuel, comprising mixing a base component with 0.5 - 50 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol. The base component may be fossil-based component and/or a renewable component. The base component may also have been obtained by co-processing one or more fossil feeds with one or more renewable feeds. Additionally, also recycled feeds may be used. The various embodiments and alternatives described above in connection with the marine fuel blend apply *mutatis mutandis* to the method for manufacturing the marine fuel. The fossil based component may be any component suitable *per se* for marine fuels, such as any of those listed above. The mixing may take place according to known methods of blending marine fuels or fuels, for example at the manufacturing facility of the marine fuel or at a point of distribution. Blending of fuel components is also possible on board.

[0041] It is to be understood that the embodiments of the invention disclosed are not limited to the particular structures, process steps, or materials disclosed herein, but are extended to equivalents thereof as would be recognized by those ordinarily skilled in the relevant arts. It should also be understood that terminology employed herein is used for the purpose of describing particular embodiments only and is not intended to be limiting.

[0042] Furthermore, the described features, structures, or characteristics may be combined in any suitable manner in one or more embodiments. In the description, numerous specific details are provided, to provide a thorough understanding of embodiments of the invention.

[0043] The verbs "to comprise" and "to include" are used in this document as open limitations that neither exclude nor require the existence of also un-recited features. The features recited in dependent claims are mutually freely combinable unless otherwise explicitly stated. Furthermore, it is to be understood that the use of "a" or "an", i.e. a singular form, throughout this document does not exclude a plurality.

EXPERIMENTAL PART

[0044] The present marine fuel blends were tested with different compositions and the resulting blends were tested for their properties. The test results are given below in Tables 1 to 4.

[0045] The RMB used in the fuel blend was a typical fossil based RMB fulfilling ISO 8217-2017 standard except for pour point (marked with *).

[0046] The RMG 1 (or RMG test sample 1) grade with maximum of 0.5 wt-% sulphur used in the fuel blend was resid hydrocracker 560 °C+ bottom oil. The other two RMG's (RMG 2 and RMG 3, or RMG test sample 2 and RMG test sample 3, respectively) were two slightly different RMG grades.

[0047] The DMB was distillate based marine fuel according to ISO 8217:2014 with ultra low (i.e. below 0.1 wt-%) sulphur content.

[0048] The refined CNSL used comprised at least 50 wt-% cardanol. Three different grades of refined CNSL were used, namely CNSL 1, CNSL 2 and CNSL 3. The CNSL 2 was a purer grade than CNSL 3.

[0049] The measurement methods were as follows:

Density at 15 °C: ISO 12185:1996
Pour point for RMB: ASTM D5950-14(2020)
Pour point for RMG: ISO 3016:2019
Kinematic viscosity, at 50 °C: EN ISO 3104:1996
Sulphur content: ISO 8754:2003
Flash point for RMB: ISO 2719:2016, method A
Flash point for RMG: ISO 2719:2016, method B
Hydrogen sulphide: IP570:2015
Ash content: ISO 6245:2002
Carbon residue: ISO 10370:2014
Total acid number (TAN) for RMB: ISO 6619:1988
Total acid number (TAN) for RMG: ASTM D664-2018
Potential Total Sediment (TSP) for RMB and RMG: ISO 10307-2A:2009
Existent Total Sediment (TSE) for DMB: ISO 10307-1:2009
Water content (vol-% or wt-%) by potentiometric Karl Fischer titration method: ISO 10336M: 1997

[0050] Additionally, Table 1 gives the calculated carbon aromaticity index (CCAI), calculated using the following equation:

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

wherein

D= density at 15 °C (kg/m^3)
V=kinematic viscosity (mm^2/s)
t = viscosity temperature (°C)

[0051] The amount of Al, Ca, Na, P, Si, V and Zn (in mg/kg) in the blends were determined using inductively coupled plasma (ICP).

[0052] In Table 1, the column titled ISO 8217:2017(E) lists the requirements of said standard for RMB marine fuels, with the exception of the pour point, where the maximum is indicated as 30.0 °C (marked with *). Tables 1 and 2 give some characteristics of the blends as well as for the RMG 2. The requirements of ISO 8217:2017(E) for RMG marine fuels are the same as for RMB marine fuels, with the following exceptions: density maximum 991.0 kg/m^3, viscosity at 50°C 700 mm^2/s, sulphur maximum 0.5 wt-%, ash maximum 0.100 wt-% and carbon residue maximum 18 wt-%.

Table 1

Property	**Unit**	**ISO 8217: 2017(E)**	**RMB + 5 vol-% CNSL 1**	**RMB + 10 vol-% CNSL 1**	**RMB + 20 vol-% CNSL 1**
Density	kg/m^3	max 960.0	884.2	888.3	896.6
Pour point	°C	max 30 (*)	27	30	27
Viscosity at 50°C	mm^2/s	max 30	11.42	11.93	14.36
Sulphur	wt-%	max 0.10	0.09	0.08	0.07
Flash point	°C	min 60.0	122.0	125.0	126.5
Hydrogen sulphide	mg/kg	2.00			<0.40
Ash	wt-%	max 0.070	0.055	0.104	<0.001

(continued)

Property	Unit	ISO 8217: 2017(E)	RMB + 5 vol-% CNSL 1	RMB + 10 vol-% CNSL 1	RMB + 20 vol-% CNSL 1
Carbon residue	wt-%	max 10.00	0.44	0.83	1.75
TAN	mg KOH/g	max 2.5	<0.10	<0.10	<0.10
CCAI		max 860	798	801	805
TSP	wt-%	max 0.10	0.06	0.09	0.23
ICP-Al	mg/kg	Al+Si 40	4.8	9.7	
ICP-Ca	mg/kg	30	7.4	14	
ICP-Na	mg/kg	100	5.9	10	
ICP-P	mg/kg	15	5.5	11	
ICP-Si	mg/kg		7.2	14	
ICP-V	mg/kg	150	<0.5	<0.5	
ICP-Zn	mg/kg	15	<0.6	<0.6	
Water	vol-%	0.50	0.03	0.05	
Water	wt-%				0.06

Table 2

Property	Unit	RMG 2	RMG 2 + 5.2 vol-% CNSL 2	RMG 2 + 10.5 vol-% CNSL 2	RMG 2 + 5.1 vol-% CNSL 3
Density	kg/m^3	980.9	979.8	978.6	981.0
Pour point	°C	0	-3	-6	-6
Viscosity at 50°C	mm^2/s	193.5	228.1	266.4	254.2
Sulphur	wt-%	0.45	0.45	0.44	0.45
Flash point	°C	116.0	128.0	140.0	126.5
Hydrogen sulphide	mg/kg	<0.60	<0.60	<0.60	<0.60
Ash	wt-%	0.019	0.039	0.028	0.082
Carbon residue	wt-%	7.48	7.78	8.03	10.0
TAN	mg KOH/g	0.10	<0.10	<0.10	<0.10
TSP	wt-%	0.16	0.07	0.05	0.10
ICP-Al	mg/kg	24	20	19	19
ICP-Ca	mg/kg	< 3	< 3	< 3	6
ICP-Na	mg/kg	2	4	3	6
ICP-P	mg/kg	< 1	< 1	< 1	3
ICP-Si	mg/kg	13	13	14	8
ICP-V	mg/kg	17	17	17	16
ICP-Zn	mg/kg	< 1	< 1	< 1	< 1

[0053] The refined CNSL was also blended with two further different RMG grades (RMG test sample 1, i.e. RMG 1 and RMG test sample 3, i.e. RMG 3) with max 0.5 wt-% sulphur marine fuel, and TSP was measured according to ISO 10307-2A:2009. Three different CNSL's were used, CNSL 1, CNSL 2 and CNSL 3 (also named CNSL test sample 1, CNSL test sample 2 and CNSL test sample 3, respectively). Tables 3 and 4 show the results, the column titled ISO 8217:2017(E) giving the requirement of said standard for RMG marine fuels.

Table 3

Property	Unit	ISO 8217: 2017(E)	RMG 1	RMG 1 + 0.5 vol-% CNSL 1	RMG 1 + 5 vol-% CNSL 1	RMG 1 + 10 vol-% CNSL 1
TSP	wt-%	max 0.10	0.12	0.12	0.05	0.04

Table 4

Property	Unit	ISO 8217: 2017 (E)	RMG 3	RMG 3 + 10.3 vol-% CNSL 2	DMB	DMB + 9.4 vol-% CNSL 2	DMB + 9.2 vol-% CNSL 3
TSP	wt-%	max 0.10	0.10	0.04			
TSE	wt-%	max 0.10			< 0.01	< 0.01	< 0.01

[0054] The used RMG test samples RMG 1 and RMG 2 alone did not fulfil the RMG marine fuel specification ISO 8217 limit (0.10 wt-%) regarding TSP. Adding 0.5 vol-% of CNSL 1 to the RMG 1 kept the aged sediment concentration the same as without any addition. When 5 vol-% or 10 vol-% of any of the CNSL's were added to RMG 1, RMG 2 or RMG 3, TSP reduced from 0.12 wt-% to 0.05 wt-% and 0.04 wt-%, respectively for CNSL 1, from 0.16 wt-% to 0.07 wt-% and 0.05 wt-% respectively for CNSL 2, and from 0.16 wt-% to 0.10 wt-% for CNSL 3. The amount of TSP was finally well below specification limit, as the absolute reduction was from 0.07 to 0.09 wt-% when using 5 vol-% of CNSL and 0.08 to 0.11 wt-% when using 10 vol-% of CNSL.

[0055] The tested DMB had a very low amount of TSE, and this did not change when 10 wt-% of CNSL 2 or 3 was added.

Claims

1. A marine fuel blend having a kinematic viscosity of 1-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996, and comprising 0.5 - 50 vol-% of refined cashew nut shell liquid, which cashew nut shell liquid comprises at least 50 wt-% of cardanol.

2. The marine fuel blend according to claim 1, wherein the kinematic viscosity is 1-30 mm^2/s as measured at 50 °C according to EN ISO 3104:1996.

3. The marine fuel blend according to claim 2, comprising 0.5-30 vol-% of refined cashew nut shell liquid.

4. The marine fuel blend according to claim 2 or 3, having a pour point of 5-30 °C as measured by EN ISO 3016:2019.

5. The marine fuel blend according to any of the claims 2-4, having a sulphur content of at most 0.1 wt-%, as measured by ISO 8754:2003.

6. The marine fuel blend according to any one of the claims 2-5, having a Pensky-Martens flash point of over 60 °C, preferably 100-150 °C as measured by EN ISO 2719:2016.

7. The marine fuel blend according to claim 1, wherein the kinematic viscosity is 31-700 mm^2/s as measured at 50 °C according to EN ISO 3104:1996, and it comprises 0.5-20 vol-% of refined cashew nut shell liquid.

8. The marine fuel blend according to claim 7, wherein the kinematic viscosity is 90-130 mm^2/s as measured at 50 °C according to EN ISO 3104:1996.

9. The marine fuel blend according to claim 7 or 8, comprising 0.5-10 vol-% of refined cashew nut shell liquid.

10. The marine fuel blend according to any of the claims 7-9, having an amount of aged sediment of less than 0.10 wt-%, preferably 0.08 wt-% as measured by ISO 10307-2:2009.

11. The marine fuel blend according to any of the preceding claims, wherein the cashew nut shell liquid comprises at least 80 wt-% of cardanol.

12. The marine fuel blend according to any of the preceding claims, wherein the cashew nut shell liquid has been refined by any of vacuum distillation, distillation, heat treatment, filtration, degumming or combinations thereof.

13. Use of refined cashew nut shell liquid comprising at least 50 wt-% of cardanol as asphaltene stabiliser for marine bunker fuels.

14. Use of refined cashew nut shell liquid comprising at least 50 wt-% of cardanol as marine fuel component.

15. Use according to claim 14 or 15, for reducing the greenhouse gas emissions at least 4 % as CO_{2eq}/MJ calculated according to the directive 2018/2001 of the European Parliament and of the Council.

Europäisches Patentamt
European Patent Office
Office européen des brevets

EUROPEAN SEARCH REPORT

Application Number
EP 21 20 8970

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
X Y	US 2012/103303 A1 (HARTLEY JOSEPH P [GB]) 3 May 2012 (2012-05-03) * paragraphs [0008], [0009], [0035], [0052], [0086] * * claims 1, 2, 13 *	1-15 15	INV. C10L1/02
Y	Guero Mario ET AL: "Study of the biomass potential in Côte d'Ivoire", , 4 June 2021 (2021-06-04), XP055912114, Retrieved from the Internet: URL:https://www.rvo.nl/sites/default/files/2021/06/Study-of-the-biomass-potential-in-Cote-dIvoire.pdf [retrieved on 2022-04-12] * pages 13-15 *	15	
Y	Unknown: "Cashew Nutshells - A valuable Byproduct", , 3 July 2019 (2019-07-03), XP055912125, Retrieved from the Internet: URL:https://renewable-carbon.eu/news/cashew-nutshells-a-valuable-byproduct/ [retrieved on 2022-04-12] * the whole document *	15	TECHNICAL FIELDS SEARCHED (IPC) C10L
X Y	US 2016/200995 A1 (CUI ZHENG [US] ET AL) 14 July 2016 (2016-07-14) * claims 80-85, 90-92 * * paragraphs [0008], [0027] *	1-15 15	

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
The Hague	19 April 2022	Pardo Torre, J

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
Y : particularly relevant if combined with another document of the same category
A : technological background
O : non-written disclosure
P : intermediate document

T : theory or principle underlying the invention
E : earlier patent document, but published on, or after the filing date
D : document cited in the application
L : document cited for other reasons

& : member of the same patent family, corresponding document

EPO FORM 1503 03.82 (P04C01)

ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO.

EP 21 20 8970

This annex lists the patent family members relating to the patent documents cited in the above-mentioned European search report. The members are as contained in the European Patent Office EDP file on
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

19-04-2022

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2012103303 A1	03-05-2012	CA 2770772 A1	28-04-2012
		CN 102533398 A	04-07-2012
		DK 2447346 T3	24-03-2014
		EP 2447346 A1	02-05-2012
		ES 2452316 T3	31-03-2014
		JP 5855900 B2	09-02-2016
		JP 2012092339 A	17-05-2012
		SG 180142 A1	30-05-2012
		SG 190589 A1	28-06-2013
		US 2012103303 A1	03-05-2012
US 2016200995 A1	14-07-2016	CA 2921277 A1	19-02-2015
		US 2016200995 A1	14-07-2016
		WO 2015023842 A2	19-02-2015

EPO FORM P0459

For more details about this annex : see Official Journal of the European Patent Office, No. 12/82